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85% SKYWAY SUBMITTAL
DRAFT GEOTECHNICAL SUMMARY REPORT
SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

Prepared for:
CALIFORNIA DEPARTMENT OF TRANSPORTATION

February 2000

Earth Mechanics

Fugro - Earth Mechanics
A JOINT VENTURE

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February 1, 2000
Project No. 98-42-0054

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian, Contract Manager

85% Skyway Submittal
Draft Geotechnical Summary Report
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

During the 1989 Loma Prieta earthquake, the East Span of the San Francisco-Oakland Bay Bridge (SFOBB) suffered considerable damage including the collapse of one section of the upper deck. During subsequent evaluations, the California Department of Transportation (Caltrans) determined that: 1) the present bridge did not meet present day seismic safety standards; and 2) that it would be more cost-effective to replace the East Span of the bridge than it would be to retrofit it. The new bridge is to be constructed to the north of the existing structure.

To support their design efforts, Caltrans has contracted with Fugro-Earth Mechanics (a joint venture between Fugro West, Inc., and Earth Mechanics, Inc.) to conduct geotechnical and geological investigations and studies for the replacement bridge. Caltrans Contract 59A0053, dated August 27, 1997, authorized those studies. To date, six task orders have been issued under contract 59A0053. The six task orders include:

- **Task Order No. 1 -** Initial Site Characterization-Geophysical Surveys Phase with a Notice to Proceed issued January 6, 1998.
- **Task Order No. 2 -** Project Management and Coordination with a Notice to Proceed issued January 26, 1998.
- **Task Order No. 3 -** Preliminary Site Exploration and Testing with a Notice to Proceed issued January 26, 1998.
- **Task Order No. 4 -** Probabilistic Seismic Hazard Analysis Update and Preliminary Site Response Analysis with a Notice to Proceed issued May 19, 1998.
- **Task Order No. 5 -** Phase 2 Site Exploration and Characterization with a Notice to Proceed issued July 23, 1998.
- **Task Order No. 6 -** Pile Installation Demonstration Project Engineering/Monitoring with a Notice to Proceed issued December 23, 1998.

The "preliminary" phase of work (Task Order Nos. 1 through 4) included: a) compilation of existing subsurface data for the site and vicinity; b) marine and onshore geophysical surveys;

c) preliminary subsurface exploration; d) site characterization and seismic ground motion evaluation; and e) development of preliminary geotechnical foundation design recommendations. Those data were used to assist with structure type selection and preliminary design of the replacement bridge.

The ongoing "final" phase of work (Task Order Nos. 5 and 6) includes final design-phase subsurface exploration, the final site characterization, the pile installation demonstration project and the final geotechnical foundation design recommendations. The data gathered, analyses performed, and recommendations made during this phase are being used by the design team (TY Lin/Moffatt & Nichol) and Caltrans for the analyses of the proposed bridge, and to prepare plans and special provisions for the project. This Geotechnical Summary Report is being prepared as a part of the work scope authorized by Task Order No. 5. We understand that the report is to be included with the bid package for the Skyway Contract.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO WEST, INC.
(on behalf of Fugro-Earth Mechanics, a Joint Venture)

M. Jacob Chacko, P.E.
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Attachment

Copies submitted:
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1.0 INTRODUCTION

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. To date, six task orders have been issued under Contract No. 59A0053. This Geotechnical Summary report is being prepared as a part of the work scope authorized by Task Order No. 5.

This report provides a brief synopsis of the site characterization and design evaluations that have been performed for the Skyway structures, and includes a summary of:

- Other reports that have been prepared for the project;

Subsurface conditions that control pile design and installation,

Pile design recommendations; and

- Pile installation considerations.

Detailed descriptions and results of analyses are provided in the reports listed on Plate 1.

The site conditions and design recommendations reported herein are based on: a) structure information as defined by the 65-percent submittal drawings submitted by TY Lin/Moffatt and Nichol (TY Lin/M&N), and b) final "design phase" activities that have been completed to date by the Fugro-Earth Mechanics Joint Venture (Fugro-EM). This draft report, therefore, will likely need to be revised to reflect modifications to the design and possible modifications to the foundation recommendations suggested by the remaining design phase activities. Specifically, we anticipate that the recommendations provided relative to the installation of CISS piles will likely need to be reviewed on completion of the Pile Installation Demonstration Project.

2.0 PRIMARY REPORTS PREPARED FOR THE PROJECT

A number of reports have been prepared (or are in preparation) for the project by Fugro-EM. The flowchart presented on Plate 1 has been prepared to clarify and delineate the areas and issues addressed (or to be addressed) by the primary reports prepared (or to be prepared) for the project by Fugro-EM.

2.1 REPORT TOPICS

As shown on Plate 1, the project submittals have generally been divided into: a) geotechnical site characterization reports, and b) foundation design reports. The site characterization submittals consist of: a) marine, b) Oakland Shore Approach, and c) Yerba Buena Island reports. Final foundation reports will be prepared to address: a) the Yerba Buena Island transition structures and Main Span-Pylon, b) the Main Span-East Pier and Skyway Piers (E3 through E16), and c) the Oakland Shore Approach structures to the east of Pier E16. In general, foundation design recommendations and results are developed interactively and iteratively with the structural engineers. Since the design loads and foundation layouts are still being modified, most of the foundation reports are still in preparation. Design recommendations are typically being provided to the design team via memoranda and will be included in the final foundation reports.

2.2 REPRESENTATIVE AREAS

The areas addressed by the various site characterization and foundation reports are shown schematically on Plate 2. As shown on Plate 2, the delineation of areas addressed by the site characterization reports is generally based on the site investigation techniques used. Since marine investigation techniques were used to the north of the Oakland Mole, there is some overlap between the areas addressed in the Marine and Oakland Mole site characterization reports. In contrast, the areas addressed by the final foundation reports are based on: a) the subsurface conditions (as defined in the site characterization reports), and b) the requirements of the various bridge and structural engineering teams. Consequently, the break-up of areas addressed in each of the foundation reports is somewhat different from the break-up of areas addressed in each of the site characterization reports.

2.3 FINAL REPORTS

Reports that are (or will be) considered to represent the final submittal for a particular issue or area are shaded gray on Plate 1. Those reports either stand alone or generally supercede previous reports prepared on that topic.

2.4 REPORTS APPLICABLE TO THE SKYWAY STRUCTURES

Of the various documents listed on Plate 1, those that fall under the following headings are considered to be directly applicable to the Skyway contract:

- Marine geophysical and geotechnical reports;
Seismic ground motion reports;
Main Span-East Pier, and Skyway Structure Pile Design Reports; and
- Pile Installation Demonstration Project (PIDP) reports.

2.5 REPORT PURCHASE PROCESS

The various reports produced by Fugro-EM for the project may be purchased by contractors bidding for the project. The particulars for that process are currently being evaluated by Caltrans and will be detailed when this draft report is finalized.

3.0 SUBSURFACE CONDITIONS

3.1 BASIS OF CHARACTERIZATION

The description of the subsurface conditions is based primarily on:

- 30 marine borings drilled in late August through early November 1998;
14 marine borings drilled in late February through early April 1998;
2-D and 3-D geophysical surveys conducted in January and February 1998;
Various borings completed from 1994 through 1996 for the Caltrans' retrofit studies; and
- Other historical drilling information.

The location of the various explorations used in our interpretations is shown on Plate 3. For our interpretations, we have placed primary emphasis on the site-specific conditions encountered in the 1998 borings and the subsurface geometry imaged by the marine geophysical survey (Fugro-EM, 1998a,b, 1999b). The 1998 borings include extensive in situ and laboratory test data (on relatively undisturbed push samples), while the older borings include variable quantities of test data (on comparatively disturbed driven samples).

3.2 ROCK CORE AND SAMPLE VIEWING

A number of soil and rock samples were collected during the Phase 1 and Phase 2 site investigation programs conducted by Fugro-EM. Several of those were used for laboratory testing as a part of the site characterization process. The remainders of those samples (if any) and untested samples are available for viewing by contractors bidding for the project. The particulars for that process are currently being evaluated by Caltrans and will be detailed when this draft report is finalized.

3.3 GEOLOGIC CHARACTERISTICS

The primary geologic formations that underlie the Skyway alignment (or portions of the alignment) are listed below in descending sequence. While the formation designations are useful, we have chosen to also describe the subsurface conditions primarily in terms of undrained shear strength (of cohesive soils) and relative density or measured cone tip resistance (of granular soils). That choice was made based on the extensive test data from the 1998 Fugro borings and the direct applicability of the test data to foundation design. The typical soil designations for the formations are also included in the following table:

Formation Designation	Typical Soil Designation
Young Bay Mud	Very Soft to Soft or Soft to Firm Clay
Merritt-Posey-San Antonio Formations (also referred to as Merritt Sand)	Dense to Very Dense Sand with Stiff to Very Stiff Clay Layers
Old Bay Mud	Very Stiff to Hard Clay with Dense Sand Layers
Upper Alameda Sediments	Very Stiff to Hard Clay With Dense Sand Layers
Lower Alameda Sediments	Dense to Very Dense Sand (or Very Dense Sand) and Hard Clay

The stratigraphy in the borings has been compared and integrated with the stratigraphic relationships as imaged by the geophysical surveys. That integrated effort has been used to prepare surface contour and isopach (thickness) contour maps for various stratigraphic horizons and stratigraphic units that underlie the site. Those interpreted maps are included in the August 1999 Final 3-D Marine Geophysical Survey report (Fugro-EM, 1999b). The soil lithologies encountered in the borings, data from the borings, and the interpreted stratigraphic contacts (as imaged on the marine geophysical records) were used to prepare a series of subsurface cross sections. Those cross sections are included in the February 2000 Final Marine Geotechnical Site Characterization report (Fugro-EM, 2000).

3.4 IDEALIZED SOIL PROFILES

As shown on Plate 3, borings performed during the Phase 2 investigations for the project were generally drilled at pier locations. Those borings were used to develop idealized profiles for each eastbound and westbound Skyway structure pier. However, the drilling program was not scoped to include borings under both the eastbound and westbound piers. Consequently, at many of the piers, the idealized profiles are based on extrapolation of conditions encountered at adjacent complementary pier locations and the next piers to the east and west. The structure contour maps and subsurface cross sections generated during the integrated site characterization activities (Fugro-EM, 1999b, 2000) helped provide a basis for the extrapolation of subsurface conditions.

The idealized profiles are provided in pier-specific plates in the Axial Pile Design and Drivability Report (Fugro-EM 1999a). Those profiles (which include soil stratigraphy, a design unit weight profile, and a design shear strength profile) are reproduced in Appendix A of this report.

3.5 SUBSURFACE VARIABILITY

The proposed N6 alignment is underlain by variable subsurface conditions that are intrinsic to any replacement bridge alignment to the north of the existing bridge. Some of the sources of spatial variation in subsurface stratigraphy and their implications are discussed in the Final Marine Geotechnical Site Characterization Report (Fugro-EM, 2000). Those variations include (but are not limited to) variations in the shallow stratigraphy due to channeling and variations in the deeper pile bearing stratum.

3.5.1 Variations in Shallow Stratigraphy Due to Channeling

The project area contains a series of nested, buried paleochannels. Because of the shallow channeling, variations in the thickness of surficial very soft to soft clay and the presence or absence of near-surface sand layers are inevitable beneath the Skyway alignment. This juxtaposition will produce significant subsurface variation across and along the N6 alignment down to at least elevation (El.) -24 meters. Those variations may occur across the width of an individual pier, between adjacent piers, and/or between adjacent Skyway frames.

3.5.2 Variations in the Pile Bearing Stratum

Pile foundations to support the Skyway structure will likely bear within the sand layers of the Lower Alameda Alluvial Formation (LAA-sand). Both the variation of the top elevation of the LAA-sand and the local presence or absence of LAA-clay interbeds within the underlying LAA-sand are intrinsic variations of the deposit. Because these are local variations, it is impractical to expect to predict how those variations occur over the football-field-sized area circumscribed by the loci of the pile tips at each set of piers. Thus, the pile design and construction will need to accommodate these variations.

4.0 PIER-SPECIFIC FOUNDATION ANALYSES AND DESIGN

4.1 PILE TYPE

The Preliminary Marine Geotechnical Site Characterization studies (Fugro-EM, 1998c) recognized that variability of the subsurface conditions will significantly affect the site response and the lateral load deflection response of the foundation. From a geotechnical standpoint, a foundation design that reduces the sensitivity of the foundation (and superstructure) response to those inevitable variations across and along the Skyway was recommended. The choice (by TY Lin/M&N) of battered, large-diameter, Cast-In-Steel-Shell (CISS) piles is considered consistent with the inevitable variability of the subsurface. The CISS piles consist of steel pipe piles that will be driven open ended and will subsequently be partially filled with concrete.

The foundation layouts provided in the 65-percent design submittal (TY Lin/M&N, 1999c,d) indicate that each of the adjacent eastbound and westbound piers for Piers E3 through E14 are supported by a group of six batter piles. Piers E15 and E16 are supported by groups of four batter piles. The area circumscribed by the loci of the pile tips for each pair of Skyway piers will be on the order of the area of a football field.

4.2 TARGET PILE TIP ELEVATION

Target pile tip elevations are provided on Sheet 006A - Pile Data Table of the Project Specifications (TY Lin/M&N, 1999c). The pile design for the Skyway foundations relies on the presence of a predominantly granular, end-bearing stratum in the Lower Alameda Alluvial (LAA) sequence. The top of that first significant dense sand layer (termed the LAA-sand) typically occurs at about El. -89 to El. -92 meters beneath the Skyway alignment. The proposed target pile tip elevations provided on Plate 5.4 of the Axial Pile Design and Drivability Report (Fugro-EM, 1999a) and also reproduced in the Pile Data table of the project plans are based on piles tipped about 4 meters below the anticipated top of the LAA-sand at each pier.

4.3 AXIAL PILE DESIGN ANALYSES AND RESULTS

The design of CISS piles for the Skyway structure is based on axial load-carrying capacity under service loads that is largely developed by skin friction at relatively small pile deflections. Additional axial capacity in end bearing can be mobilized (albeit at larger pile deflections) when piles are subjected to extreme loads. The estimated ultimate tension and compression capacity for static loading conditions is presented along with the estimated pile tip elevations on Plate 5.4 of the Axial Pile Design and Drivability Report.

The basis for and results of our static axial capacity and axial load-deformation analyses are presented in the Axial Pile Design and Drivability Report (Fugro-EM, 1999a). Similarly, the basis and results of our lateral load-deformation analyses are presented in the Lateral Axial Pile

Design Report (Fugro-EM, 1999c). The results are provided on a series of illustrations for each pier in the pier-specific appendices of those reports.

4.4 PILE DRIVABILITY ANALYSES

To assist with the preparation of foundation design and construction recommendations, preliminary pile drivability analyses were performed for a few of the Skyway piers. The analyses were conducted using the anticipated pile wall schedules, as shown in the 45-percent drawings (TY Lin/M&N, 1999a,b). Three large offshore hammers were considered: 1) a 550-kilonewton-meter (kN-m) Menck MHU-500T, 2) a 1,000-kN-m Menck MHU-1000, and 3) a 1,670-kN-m Menck MHU-1700. When drivability analyses were performed for a pier, the results were provided with the pier-specific axial design results in the Axial Pile Design and Drivability Report (Fugro-EMI, 1999a).

5.0 CONSTRUCTION ISSUES

5.1 GENERAL

The construction of CISS piles for the Skyway structure will need to take into consideration several site-specific and design issues. These include (but are not limited to):

- Soft near-surface soils that allow piles to penetrate significant distances under self-weight and the weight of the hammer;

Possible local variations in soil conditions;

Possible dense soils above the pile tip elevations that result in relatively hard driving;

Soils that gain strength during delays in driving and pile splicing;

Possible subsurface debris;

Wind and wave excitation;

Tidal flow fluctuation; and

Required batter.

5.2 DRIVING SYSTEM SUBMITTAL

Prior to installing driven piling, the Contractor should provide a driving system submittal, including drivability analysis, in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings," of the Standard Specifications. All proposed driving systems (i.e., each hammer that may be brought onto the site) should be included in the submittal. We recommend that a minimum of 3 weeks be provided for review of the driving system submittal.

The driving system submittal should contain an analysis showing that the proposed driving systems will install piling to the specified tip elevation in accordance with the criteria described in the subsequent sections. Drivability analyses should be performed for each eastbound and westbound pier of the Skyway.

Drivability studies included in the submittal should be based on wave equation analysis using a computer program that has been approved by the Engineer. The analysis should be performed for the pile-schedule shown on the plans. Drivability studies should model the Contractor's proposed driving systems (including the hammers, capblocks, and pile cushions) as well as determine driving resistance and pile stresses for assumed site conditions. As described in Fugro-EM (1999a) lower- and upper-bound values of soil resistance to driving should be computed for both plugged and coring cases. Drivability analyses should be performed for: a) those estimated values of soil resistance to driving; and b) for tip elevations ranging from 4 meters above to 4 meters below the predicted pile tip elevations shown in Fugro-EM (1999a).

Separate analyses shall be completed at elevations above the specified tip elevations where difficult driving or pile add-ons are anticipated.. At a minimum, submittals should include the following:

- Complete description of soil parameters used, including soil quake and damping coefficients, distribution of skin friction, total shaft friction, and total soil resistance to driving.
- List of all hammer operation parameters assumed in the analysis, including rated energy, stroke limitations, and hammer efficiency.
- Completed "Pile and Driving Data Form".
- Estimates of Pile penetration due to self weight and the weight of the hammer.

Predicted blow counts for upper and lower bound estimates of soil resistance to driving for coring and plugged cases.

Plots shall include the following:

1. Pile compressive stress versus blows per 250 millimeters (mm)
2. Pile tensile stress versus blows per 250 mm
3. Soil resistance to driving versus blows per 250 mm

- Copies of all test results from any previous pile load tests, dynamic monitoring, and all driving records used in the analyses.

5.3 DYNAMIC MONITORING

We recommend that the first 10 driven piles and the first pile at each pier thereafter (at a location selected by the Engineer) be monitored during the final 10 meters of driving above the target tip elevation for dynamic response to the driving equipment. Dynamic monitoring should be performed with a Case-Goble Pile-Driving Analyzer (PDA). The special provisions should include provisions for the installation of instruments during pile driving.

5.4 PILE ACCEPTANCE CRITERIA

We recommend that piles driven to design penetration based upon static pile capacity curves and applicable factors of safety be accepted unless the minimum blow count criteria is not satisfied. If a pile reaches refusal short of design penetration, pile acceptance should be evaluated by a geotechnical engineer before remedial installation procedures are undertaken. When techniques other than driving are used to advance the pile, conditions assumed in the computation of ultimate pile capacity based on driving alone may not be met, and pile capacities may have to be recomputed to more closely reflect the actual installation procedure.

Piles driven to refusal above design penetration can be accepted if dynamic monitoring indicates that the required compressive and tensile capacities are mobilized. In cases where the required compressive and tensile capacities are not mobilized, remedial measures should be performed, unless dynamic monitoring indicates unsatisfactory hammer performance. In cases where refusal is the result of unsatisfactory hammer performance, the problem should be corrected, and the pile redriven.

5.4.1 Minimum Bearing Capacity Criteria

We recommend using the following minimum blow count criteria in place of a minimum bearing capacity criteria.

5.4.2 Minimum Blow Count Criteria

We recommend that a minimum blow count criteria is established to ensure that the pile reaches adequate axial capacity. If the piles do not reach sufficient capacity at the specified tip elevation, the pile will need to be driven further such that the piles achieve the specified design capacity.

As minimum criteria, we recommend that the blow count during continuous driving should exceed the predicted lower-bound, coring case blow count. If the predicted lower-bound, coring case blow count is not exceeded, a 5-meter section should be added on and the pile should be driven until the minimum blow count is exceeded with satisfactory hammer performance. (A summary of the minimum allowable blow counts predicted for Menck MHU 500T, Menck MHU 1000, and Menck MHU 1700 hammers during our preliminary drivability analyses is provided in the Axial Pile Design and Drivability Report (Fugro-EM, 1999a)]

We note that minimum blow count criterion is included to reduce potential for the foundation design to be impacted by variability in the depth to pile bearing strata. The criterion is based on lower-bound coring case in order to model the degradation of soil resistance during pile driving. In our opinion, values of blow count that are less than the recommended minimum will suggest that pile tips are above the desired pile bearing stratum. Redriving the pile after a waiting period will likely result in a higher blow count due to pile set up. However, since the pile tips are likely above the desired bearing stratum, those higher blow counts will likely not negate the need to add to the pile length as recommended above.

5.5 ALLOWABLE DRIVING STRESS CRITERIA

Generally, the highest stress level in the life of a pile occurs during driving. For efficient utilization of both the pile driving hammer and pile material, it is desirable to stress the pile to the practical limit during driving. The high strain rate and temporary nature of the loading allow a substantially higher allowable stress than for static loading.

When pile driving is monitored, we recommend that driving generally be terminated when the maximum driving stress is greater than 0.9 f_y, where f_y is the yield strength of the steel. The accuracy of the measured force and velocity signals is typically ±5 percent.

5.6 SATISFACTORY HAMMER PERFORMANCE

API RP 2A does state that "refusal is contingent upon the hammer being operated at the pressure and rate recommended by the manufacturer." We recommend that satisfactory hammer performance be defined by the hammer efficiency or the energy delivered to the pile. When refusal occurs and the driving system performance is inadequate, the hammer or cushion should be changed before remedial measures are undertaken.

5.7 REFUSAL CRITERIA

The reasons for defining pile refusal are given in Sec. 12.5.6 of API RP 2A (1993a,b):

> "The definition of pile refusal is primarily for contractual purposes to define the point where pile driving with a particular hammer should be stopped and other methods instituted (such as drilling, jetting, or using a larger hammer) and to prevent damage to the pile and hammer. The definition of refusal should also be adapted to the individual soil characteristics anticipated for the specific location. Refusal should be defined for all hammer sizes to be used and is contingent upon the hammer being operated at the pressure and rate recommended by the manufacturer."

An example definition is:

> "Pile driving refusal is defined as the point where pile driving resistance exceeds either 300 blows per foot (0.3 meter) for five consecutive feet (1.5 meters) or 800 blows for one foot (0.3 meter) of penetration.

> "If there has been a delay in pile driving operations for one hour or longer, the refusal criteria stated above shall not apply until the pile has been advanced at least one foot (0.3 meter) following the resumption of pile driving. However, in no case shall the blow count exceed 800 blows for six inches (152 mm) of penetration."

We recommend that the pile refusal criteria given in Sec. 12.5.6 of API RP 2A (1993a,b) be used to define pile refusal. This definition should only apply when the hammer performance is satisfactory.

When the API RP 2A definition of refusal is used, driving stresses should be reduced to an acceptable level by proper selection of the pile wall thickness schedule and pile driving hammer. When driving stresses are excessive, however, pile driving should be terminated before refusal is obtained.

5.8 ACCEPTABLE HAMMER TYPES

We recommend that CISS piles be installed with impact hammers that are approved in writing by the Engineer. Impact hammers should be air/steam, hydraulic, or diesel. In our opinion, vibratory hammers and oscillating hammers will likely be inadequate and should not be used for the installation of piles. The primary hammer should provide a minimum energy of 1,000 kilojoules and transmit sufficient energy to drive the piles at a penetration rate of not less than 3 millimeters per blow at the specified bearing value.

The minimum hammer efficiency is dependent on the type of hammer selected. The hammer efficiency is defined as the ratio of the calculated stroke to the maximum stroke. The system efficiency is defined as the ratio of the measured energy transmitted to the pile to the rated hammer energy. Recommended minimum values of hammer and system efficiency are tabulated below:

Hammer Type	Hammer Efficiency (%)	System Efficiency (%)
Air/Steam	65	40
Hydraulic	90	70
Diesel	55	35

5.9 JETTING AND DRILLING

The computed ultimate pile capacities that were used for the design of piles were based on the assumption that piles will be driven to the desired penetration without supplemental drilling or jetting. Since pre-drilling may compromise the soil resistance on the pile, we recommend that the procedure not be used for the installation of CISS piles.

In the event that a pile has met refusal to driving above design penetration, jetting or drilling may be used to remove the soil plug. Jetting or drilling should not be allowed to disturb the soil in advance of the pile toe. Jetting or drilling should be used only with the approval of the Engineer.

If jetting or drilling is required, we recommend that it be the responsibility of the Contractor to maintain standard logs and submit copies of these logs to the Engineer. Procedures for jetting or drilling should be submitted to the Engineer for approval.

5.10 PILE CLEAN OUT FOR PLACEMENT OF STRUCTURAL CONCRETE

The project plans show that piles should be cleaned out to elevations ranging from El. -63 meters to El. -71 meters. For piles driven to the specified tip elevations shown in the Pile Data table of the project plans, this will result in a soil plug that is approximately 21 to 35 meters thick. Within the limits of the Skyway structure, the clean out elevations generally fall within the Old Bay Mud/Upper Alameda Marine sediments. On the basis of our marine borings, those layers are composed primarily of very stiff to hard fine-grained materials with a few dense sand layers.

To reduce the potential for deterioration of the top of the soil plug, we recommend that a positive hydrostatic head be maintained inside the pile during clean out and concrete placement. The placement of concrete should be performed expeditiously to reduce the potential for deterioration of the foundation material.

6.0 REFERENCES

American Petroleum Institute (API) (1993a), Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design, API Recommended Practice 2A-LRFD (RP 2A-LRFD), 1st Ed., API, Washington, DC.

______ (1993b), Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms - Working Stress Design, API Recommended Practice 2A-WSD (RP 2S-WSD), 20th Ed., API, Washington, D.C.

Fugro-Earth Mechanics (Fugro-EM) (1998a), *Preliminary Marine Geophysical Survey Summary, San Francisco-Oakland Bay Bridge East Span Replacement Project*, FWI Job No. 98-42-0018, prepared for California Department of Transportation, March 20.

______ (1998b), *Final 2-D Marine Geophysical Survey, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project*, FWI Job No. 98-42-0018, prepared for California Department of Transportation, June 20.

______ (1998c), *Preliminary Marine Geotechnical Site Characterization, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Volumes 1, 2A, and 2B*, FWI Job No. 98-42-0035, prepared for California Department of Transportation, June 23.

______ (1999a), *Revised Draft Axial Pile Design and Drivability, Main Span-East Pier & Skyway Structures, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project*, FWI Job No. 98-42-0054, prepared for California Department of Transportation, August 25.

______ (1999b), *Final 3-D Marine Geophysical Survey, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project*, FWI Job No. 98-42-0054, prepared for California Department of Transportation, August 27.

______ (1999c), *Draft Lateral Pile Design for Main Span Pier E2 & Skyway Structure, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project,* EMI Project 98-145, prepared for California Department of Transportation, October 7.

______ (2000), *Draft Final Marine Geotechnical Site Characterization, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Volume 1 - Main Text*, FWI Job No. 98-42-0054, prepared for California Department of Transportation, February 1.

TY Lin/Moffatt & Nichol (TY Lin/M&N) (1999a), *The San Francisco-Oakland Bay Bridge East Span Seismic Safety Project 45% Submittal*, *Skyway Structure*, project plans for construction on state highway, prepared for California Department of Transportation, January 15.

______ (1999b), *The San Francisco-Oakland Bay Bridge East Span Seismic Safety Project 45% Submittal*, *Main Span Structure*, project plans for construction on state highway, prepared for California Department of Transportation, January 15.

______ (1999c), *The San Francisco-Oakland Bay Bridge East Span Seismic Safety Project 65% Submittal*, *Skyway Structure*, project plans for construction on state highway, prepared for California Department of Transportation, July 15.

______ (1999d), *The San Francisco-Oakland Bay Bridge East Span Seismic Safety Project 65% Submittal*, *Main Span Structure*, project plans for construction on state highway, prepared for California Department of Transportation, August 2.

PLATES

SFOBB Task Order No. 5
Project No. 98-42-0054

FUGRO-EM GEOTECHNICAL STUDY

Site Characterization Information

Onshore Site Characterization Reports

Oakland Shore Approach Site Characterization Reports

The Oakland Shore Approach reports address the portions of the proposed N6 alignment that are on the Oakland Mole or within the tidal flat zone to the north of the Oakland Mole. The data provided are applicable to the structure-supported portion of the bridge at the west end of the mole, and to the fill-supported portions farther east.

Preliminary Oakland Shore Approach Geotechnical Site Characterization - provides preliminary information on the basis of limited Phase 1 field investigation and available pre-1998 geotechnical boring data. 6/21/98

Final Oakland Shore Approach Geotechnical Site Characterization - provides a detailed site characterization for the Oakland Mole on the basis of Phase 2 site investigation. Additionally, the report provides the results of liquefaction and lateral spread analyses performed in this area.

Vol 1 - Main Text and Illustrations
Vol 2A and 2B - By-boring Appendices
Vol 3 - CPT Sounding Appendix
Vol 4 - Additional Reports:
- Preliminary Study of Approach Fills
- Studies on Lateral Spreading of Fills
- Findings from Trench and Pit Excavation
- UC Berkeley Geotechnical Testing

8/31/99

Yerba Buena Island Site Characterization Reports

The Yerba Buena Island site characterization reports address the land-based structures at the west end of the N6 alignment. Those reports have/will address(ed) the Main Span-West Pier and various transition structures from the tunnel to the Main Span.

Preliminary Yerba Buena Island Geotechnical Site Characterization - summarizes the preliminary land-based drilling program and geophysical surveys, and provides interpretation of the subsurface conditions on the basis of integration of those data with the results of a laboratory testing program and data from pre-1998 borings. 6/23/98

Phase 1 Subcontractor Reports
Vol 2 - NORCAL Geophysical Consultants, Inc. (Seismic Surveys - Yerba Buena Island)
COLOG, Inc. (BIPS Data - Yerba Buena Island)
Hughes Insitu Engineering, Inc. (Pressuremeter Testing)
6/24/98

Interim Yerba Buena Island Site Characterization - The Phase 2 investigations on Yerba Buena Island were put on hold in October 1998 pending the availability of permits to drill on Navy property. The interim report was developed during that hiatus and provides a snapshot of the results and conclusions drawn from the investigations that had been performed at that time. 3/24/99

Final Yerba Buena Island Geotechnical Site Characterization - documents the Phase 2 investigations. The report also will provide engineering properties of soil and rock for the design of structures on Yerba Buena Island. In Preparation

Marine Site Characterization Reports

The marine site characterization reports address portions of the proposed N6 alignment over the San Francisco Bay to the east of Yerba Buena Island and to the west of the Oakland Mole. These reports describe subsurface conditions beneath: a) the Main Span-Pylon; b) Main Span-East Pier; c) the various Skyway piers; and d) over-water portions of the Oakland Shore Approach structure to the west of the Oakland Mole.

Marine Geophysical Reports

Preliminary Marine Geophysical Survey Summary - provides preliminary information relative to the field activities and preliminary interpretation of the 2-D geophysical data. 3/20/98

Preliminary Summary Report Supplement, Marine Geophysical Survey - provides additional results from the preliminary interpretation of the 2-D Geophysical data. 6/20/98

Final 2-D Marine Geophysical Survey - provides detailed interpretation of 2-D geophysical data on the basis of integration with pre-1998 and Phase 1 geotechnical borings. A number of preliminary structural contour and isopach maps of the primary geologic units are included. 6/20/98

Final 3-D Marine Geophysical Survey - provides updates and refinements to the 2-D geophysical interpretations on the basis of the Phase 2 Site Characterization program and interpretation of the 3-D geophysical survey data. The structural contour and isopach maps provided in the Final 2-D Geophysical Survey report were modified and a number of new structural contour and isopach maps were developed. Draft 8/27/99

Marine Geotechnical Reports

Interim Preliminary Marine Geotechnical Site Characterization Report - provides early during the Phase 1 investigation process as a snapshot of the results and conclusions drawn from the ongoing activities. This report was necessitated by the timing of the 30 percent cost estimate for the replacement bridge. 4/30/98

Preliminary Marine Geotechnical Site Characterization - represents the culmination of the marine Phase 1 site characterization activities. This Final Site Characterization report generally supersedes the Interim Preliminary Marine Geotechnical Site Characterization Report.
Vol 1 - Main Text and Illustrations
Vol 2A and 2B - By-boring Appendices 6/23/98

Final Marine Geotechnical Site Characterization - represents the culmination of the marine Phase 2 site characterization activities. This Final Site Characterization report generally supersedes the Preliminary Marine Geotechnical Site Characterization Report.
Vol 1 - Main Text and Illustrations Draft 2/01/00
Vol 2A through 2E - By-boring Appendices Draft 5/10/99

Phase 1 Subcontractor Reports 6/24/98

Vol 1 -	Geovision Welenco, Inc.	Borehole Geophysics Borehole Televiewer Logs
Vol 2 -	Hughes Insitu Engineering, Inc.	Pressuremeter Testing
Vol 3 -	Fugro South, Inc.	Resonant Column and Cyclic Direct Simple Shear Tests
	University of Texas at Austin	Dynamic Properties of Intact Soil Specimens
Vol 4 -	GeoTest Unlimited	Laboratory Rock Testing Program

Phase 2 Subcontractor Reports To Be Submitted

Vol 1 -	Geovision Welenco, Inc.	Borehole Geophysics Borehole Televiewer Logs
Vol 2 -	GeoTest Unlimited	Laboratory Rock Testing Program
Vol 3 -	Fugro West, Inc.	Seascout CPT soundings

Foundation Design Information

Seismic Ground Motion Reports

Seismic Ground Motion Report - provides the results of probabilistic seismic hazard analyses, and site-specific and foundation-type-specific design response spectra for the entire N6 alignment. 12/24/98

Final Seismic Hazard Ground Motion Report - will provide ground motion recommendations for the entire project. It includes probabilistic hazard studies, site response analyses, ARS design criteria, and multiple-support time histories. In Preparation

Preliminary Design Reports

Preliminary Foundation Design - provides preliminary foundation recommendations for the entire N6 alignment on the basis of the various Phase 1 (preliminary) site characterization activities. 8/31/98

Post Installation Pile Installation Demonstration (PID) Report

Post-Installation Pile Installation Demonstration Project - will document the field activities during PID program and will summarize the results and conclusions derived from the data collected during that program. To Be Prepared

Final Foundation Design Information Reports

Skyway and Main Span-East Pier

These reports provide foundation design recommendations and present construction considerations for the Main Span-East Pier (Pier E2) and Skyway Piers (E3 through E16). The reports are generally applicable to areas underlain by significant thicknesses of sediment where piers will be supported by raked, large-diameter, driven steel pipe piles.

Axial Pile Design and Drivability, Main Span-East Pier & Skyway Structures - provides pier-specific results of pile design for driven pile foundations under static axial loading conditions. The report also provides the results of pile drivability analyses and presents construction considerations for large-diameter pile foundations. Draft 8/25/99

Lateral Pile Design, Main Span-East Pier & Skyway Structures - provides pier-specific results for the design of driven piles subject to static lateral loads. The report also presents a basis for the analysis of piles under dynamic lateral loading conditions. Draft 10/7/99

YBI Approach, Main Span-West Pier and -Pylon

These reports provide foundation design recommendations and presents construction considerations for the YBI approach structures (Bents W3 through W10a), temporary detour structures, and the Main Span-West Pier and -Pylon (Pier E1). The reports are generally applicable to areas of onshore foundations or foundations supported in rock.

Rock Slope Stability Report, Main Span-West Pier and -Pylon - provides further evaluation of rock slope stability of proposed excavations for the Main Span-West Pier and -Pylon structures. 10/1/99

Yerba Buena Island Structure and Main Span-Pylon Foundation - modifications to the foundation design for structures on YBI will likely be made on the basis of the Phase 2 site characterization studies. Geotechnical recommendations for those modifications will be provided in this final foundation report. To Be Prepared

Oakland Shore Approach

Non-structural design concepts for the Oakland Shore Approach are being designed by Caltrans. No design recommendations are presented for those by Fugro-EM. Structural options (especially in marine areas) are being addressed by Fugro-EM.

Oakland Shore Approach Structure Foundation - will provide foundation design recommendations and present construction considerations for the structure-supported portions of the Oakland Shore Approach. To Be Prepared

[shaded box] = Reports that generally represent (or will represent) the final submittal for a particular issue or area.

FUGRO-EM REPORTS
SFOBB East Span Seismic Safety Project

PLATE 1

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SFOBB Task Order No. 5
Project No. 98-42-0054

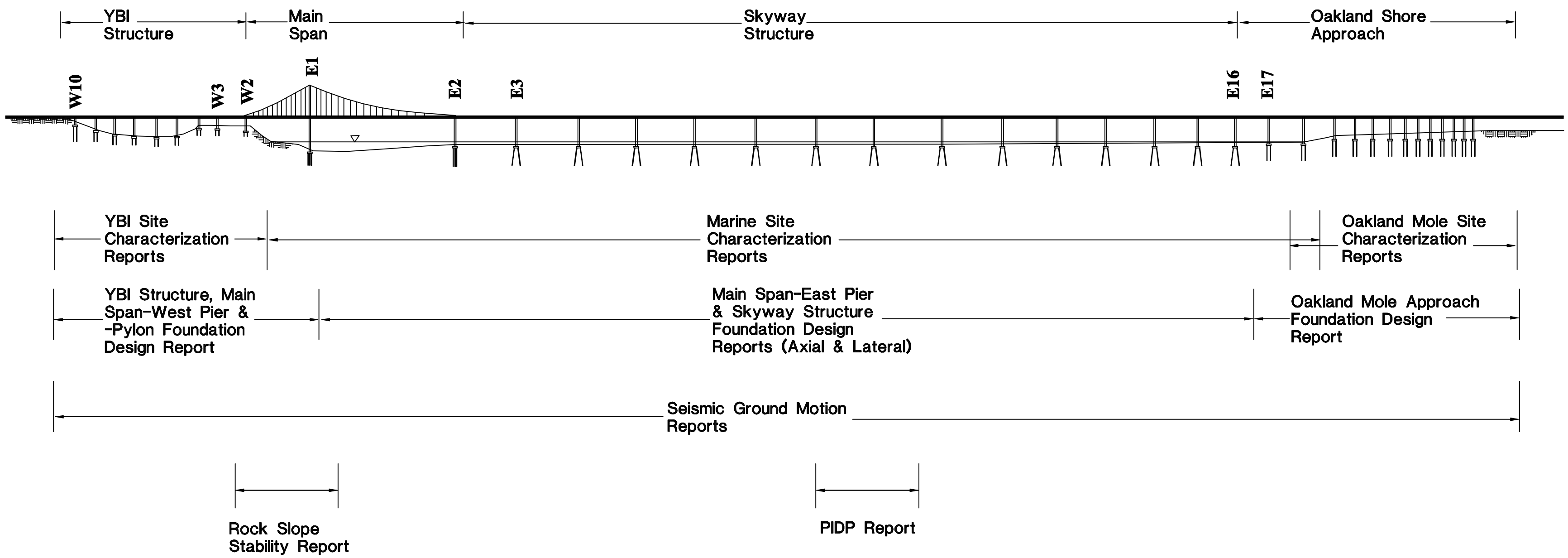
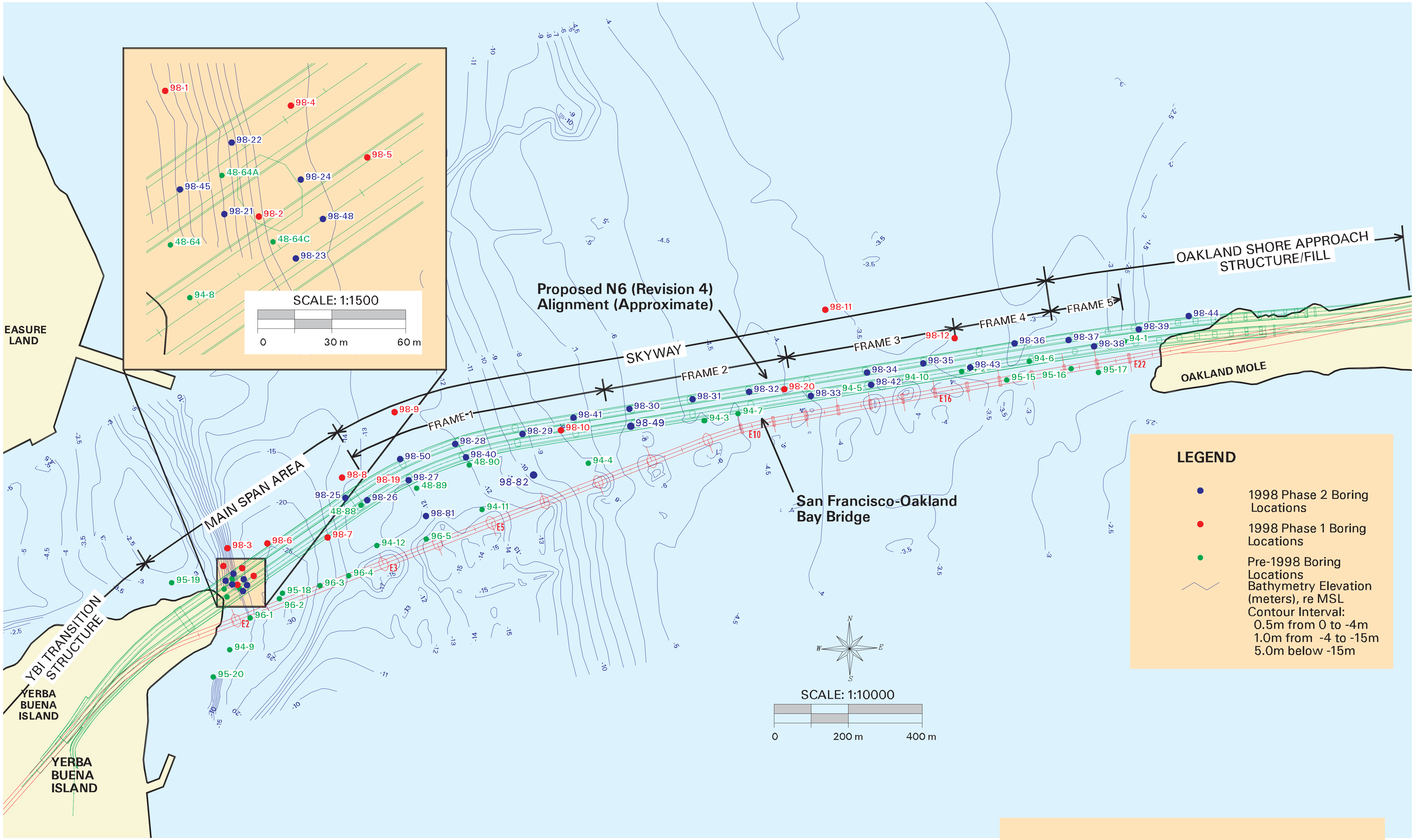


PLATE 2

DELINEATION OF AREAS ADDRESSED BY FUGRO-EM REPORTS

SFOBB East Span Seismic Safety Project

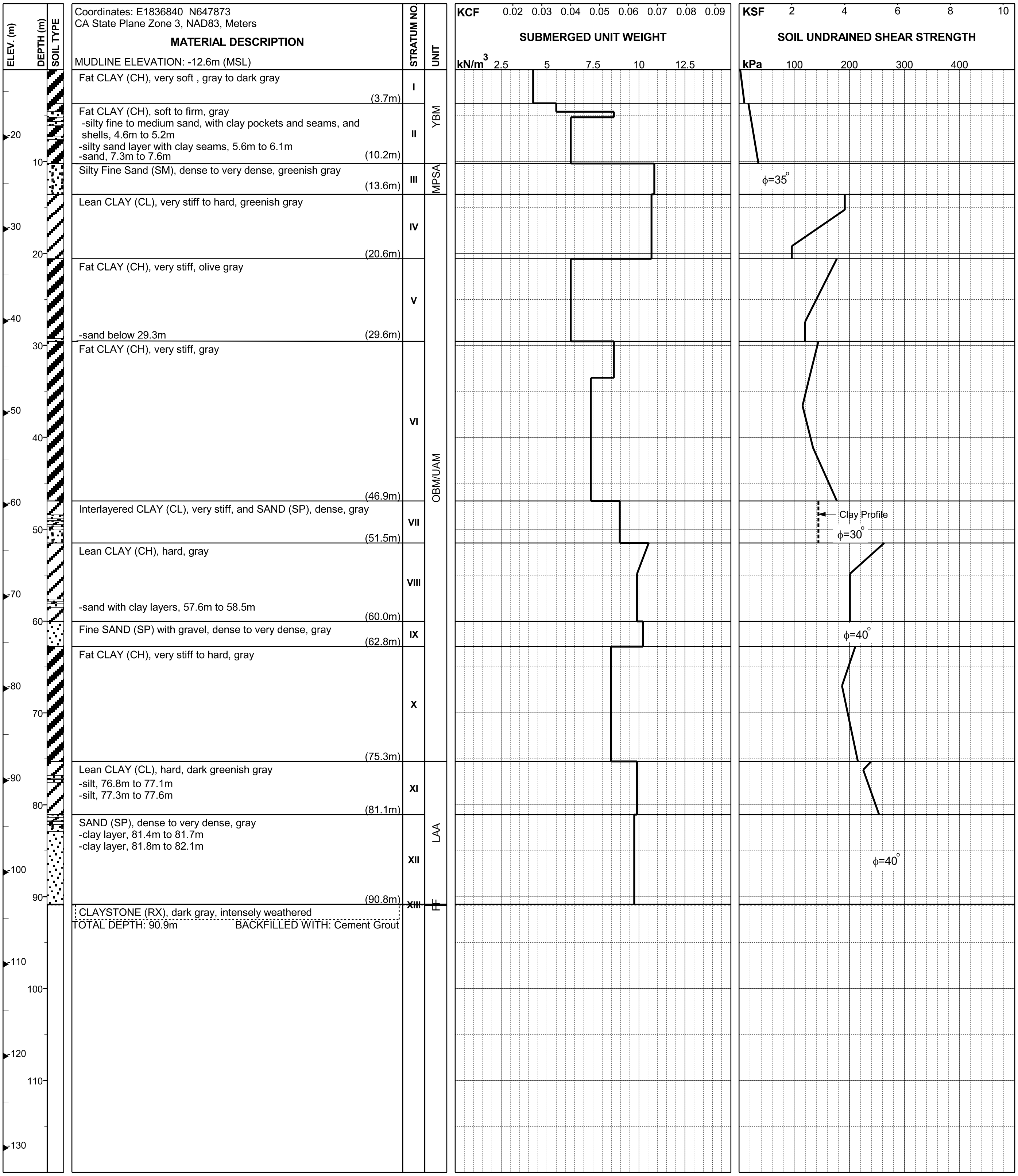


MARINE EXPLORATION LOCATION MAP
SFOBB East Span Seismic Safety Project

PLATE 3

APPENDIX A
IDEALIZED SOIL PROFILES

SFOBB Task Order No. 5
Project No. 98-42-0054

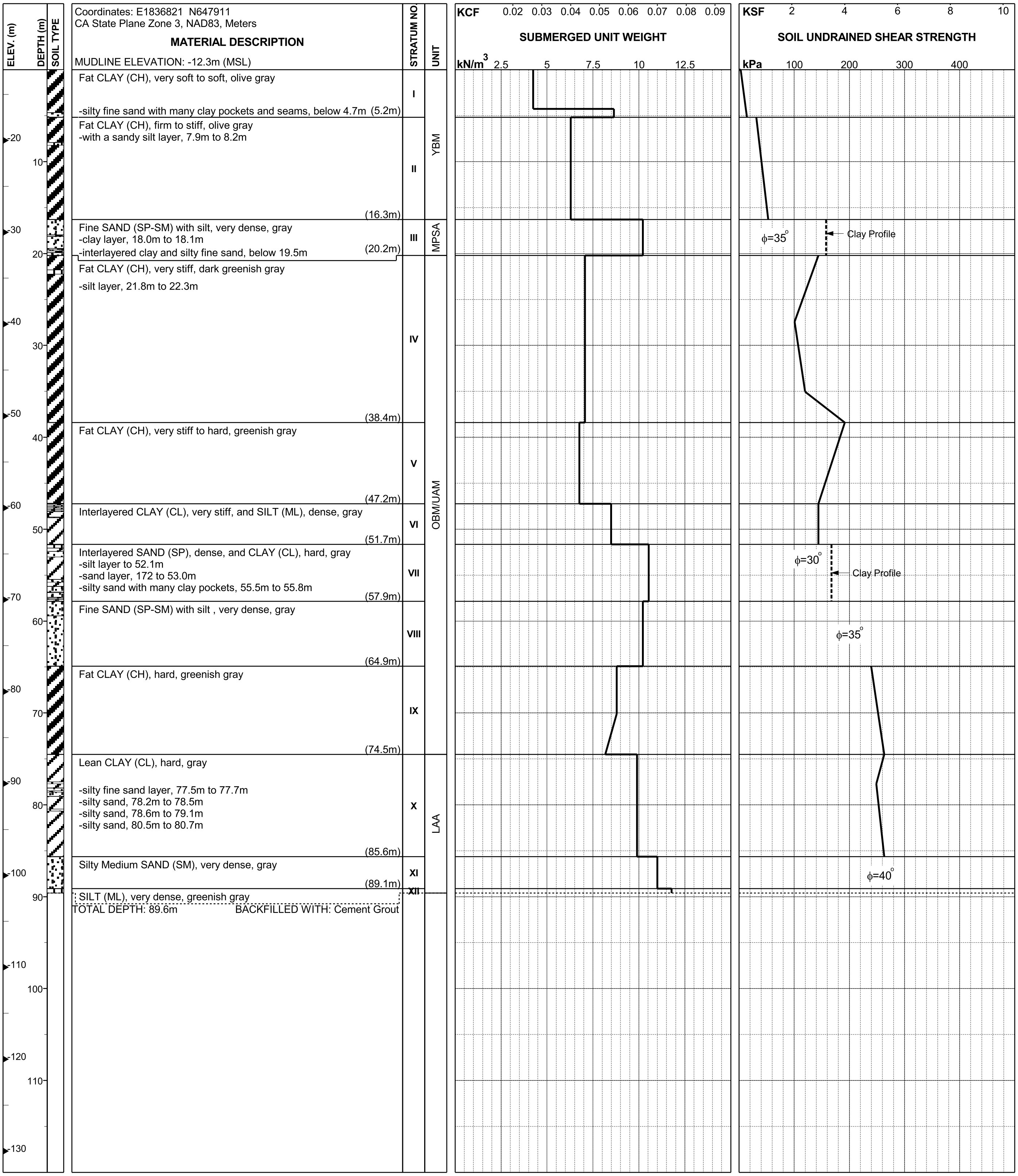


IDEALIZED SOIL PROFILE
Pier E03-EB

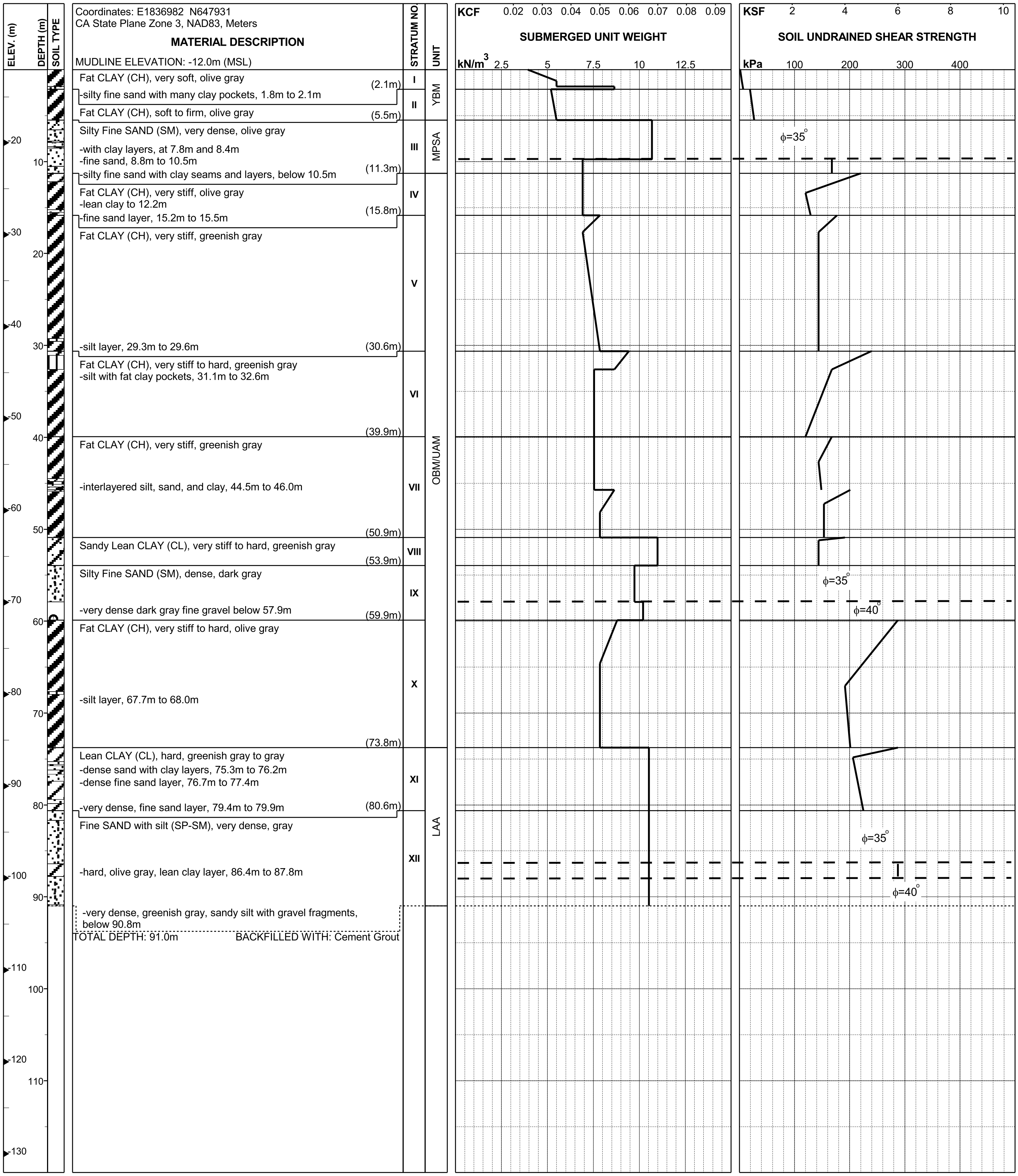
SFOBB East Span Seismic Safety Project

PLATE E03-EB

SFOBB Task Order No. 5
Project No. 98-42-0054



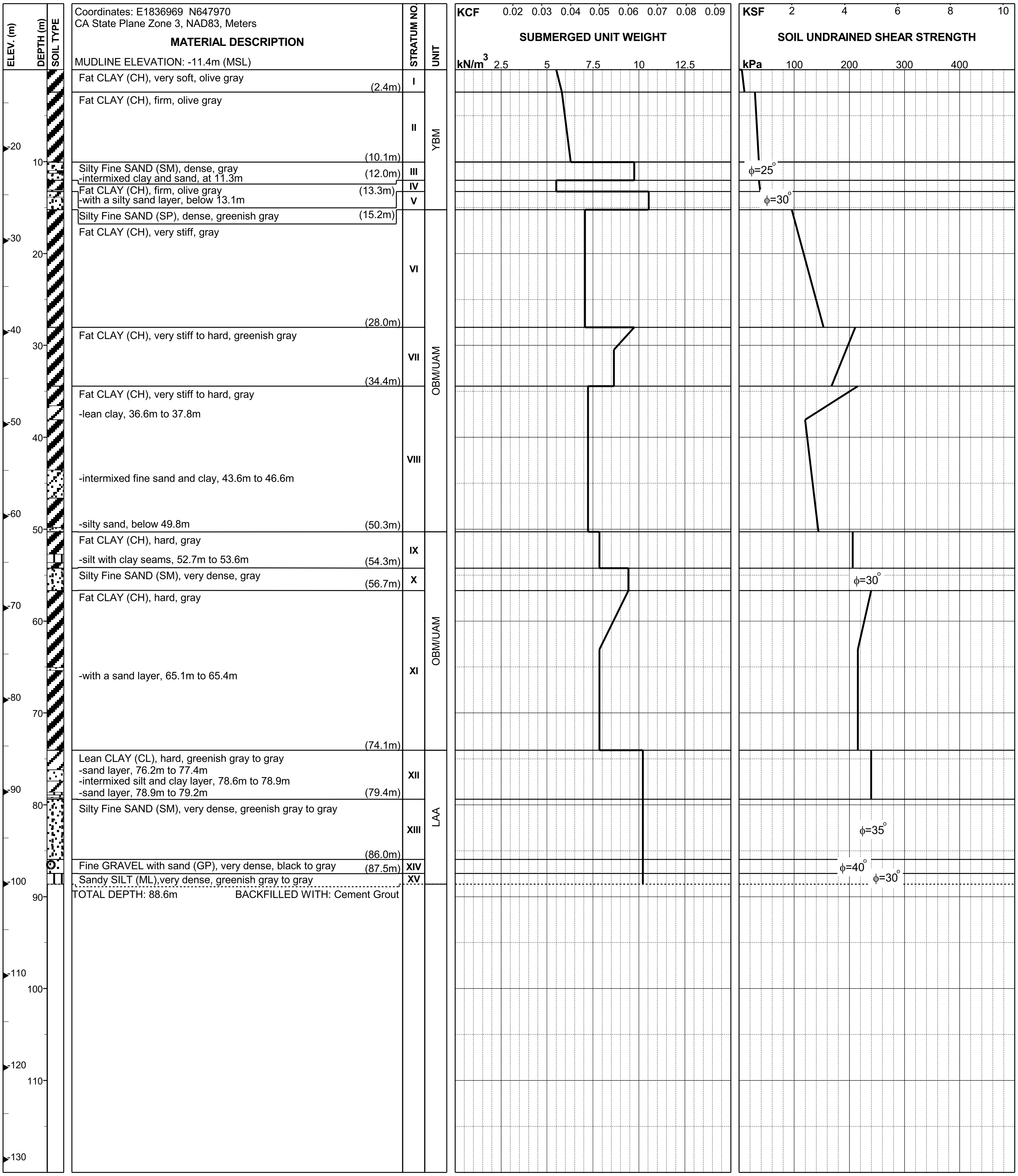
IDEALIZED SOIL PROFILE
Pier E03-WB
SFOBB East Span Seismic Safety Project



IDEALIZED SOIL PROFILE
Pier E04-EB
SFOBB East Span Seismic Safety Project

PLATE E04-EB

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E04-WB
SFOBB East Span Seismic Safety Project

PLATE E04-WB

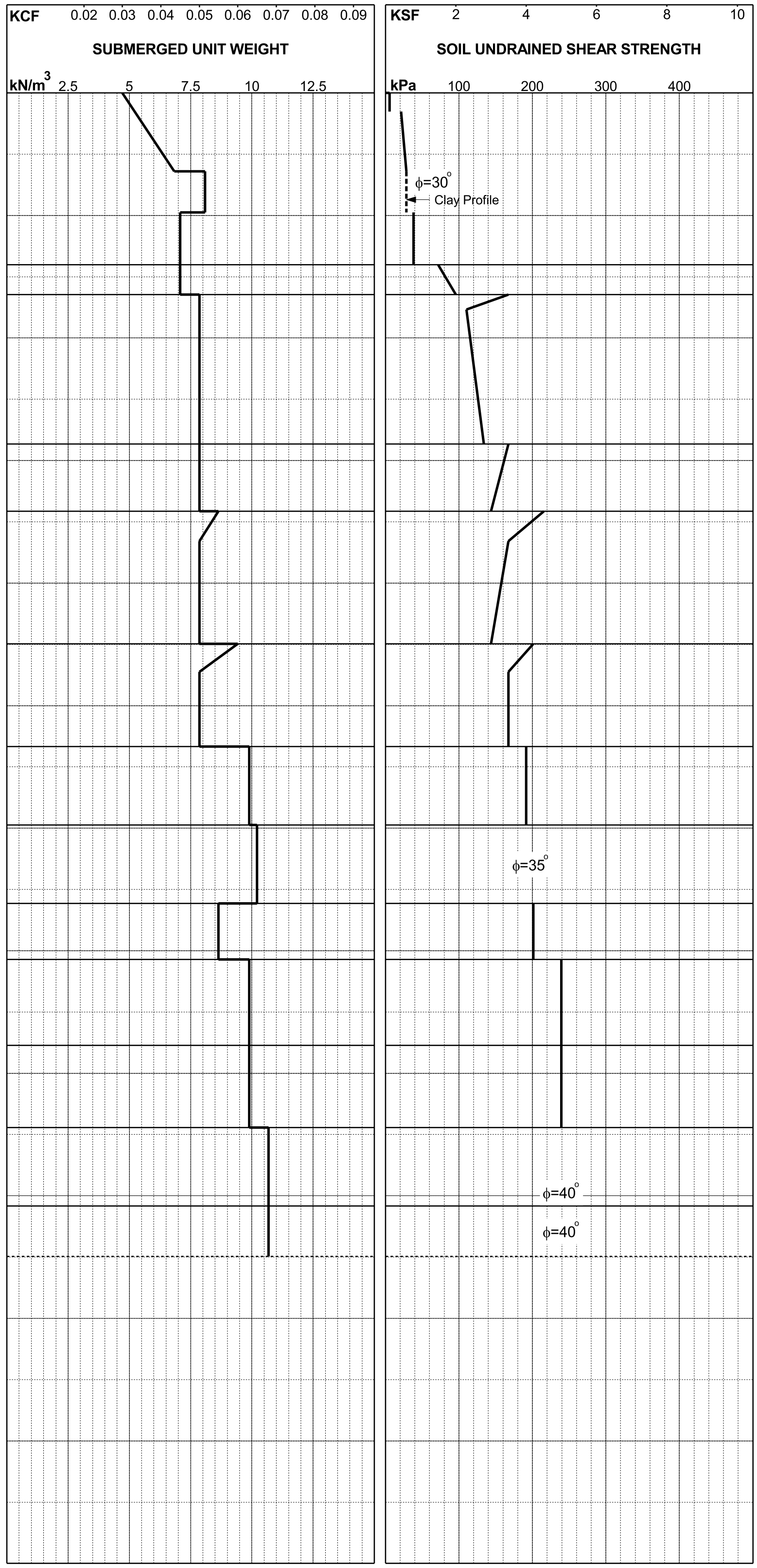
SFOBB Task Order No. 5
Project No. 98-42-0054

Coordinates: E1837131 N647968
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -9.8m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), soft to firm, dark gray -very loose, olive gray, silty fine sand layer, with many clay pockets, 0.9m to 1.2m -intermixed clay and sand, 6.4m to 7.0m -sand layer, 7.6m to 8.2m -sand layer, 8.5m to 8.8m -silty sand layer with clay pockets, 9.1m to 9.7m (14.0m)	I	YBM
Fat CLAY (CH), stiff to very stiff, olive gray to gray (16.5m)	II	MPSA
Fat CLAY (CH), very stiff, gray (28.7m)	III	OBM/UAM
Fat CLAY (CH), very stiff, gray (34.1m)	IV	OBM/UAM
Fat CLAY (CH), very stiff to hard, gray (45.0m)	V	OBM/UAM
Fat CLAY (CH), very stiff, gray -sand layer, 48.8m to 49.1m (53.3m)	VI	OBM/UAM
Lean CLAY (CL), very stiff to hard, greenish gray (59.7m)	VII	OBM/UAM
Fine to Coarse SAND with silt (SW-SM), dense, gray -silty fine sand below 64.2m (66.1m)	VIII	OBM/UAM
Lean CLAY (CL), very stiff to hard, olive gray (70.7m)	IX	OBM/UAM
Lean CLAY (CL), hard, olive gray (77.7m)	X	OBM/UAM
Lean CLAY (CL), hard, gray -interlayered sand and clay, below 82.9m (84.4m)	XI	LAA
Fine to Medium SAND with silt (SP-SM), dense to very dense, gray (90.8m)	XII	LAA
Fine GRAVEL (GP), very dense, dark gray -sand layer, 91.4m to 92.4m -dense to very dense, fine to coarse sand, at 94.8m	XIII	LAA

TOTAL DEPTH: 94.9m BACKFILLED WITH: Cement Grout



IDEALIZED SOIL PROFILE
Pier E05-EB
SFOBB East Span Seismic Safety Project

PLATE E05-EB

SFOBB Task Order No. 5
Project No. 98-42-0054

Coordinates: E1837125 N648007
CA State Plane Zone 3, NAD83, Meters

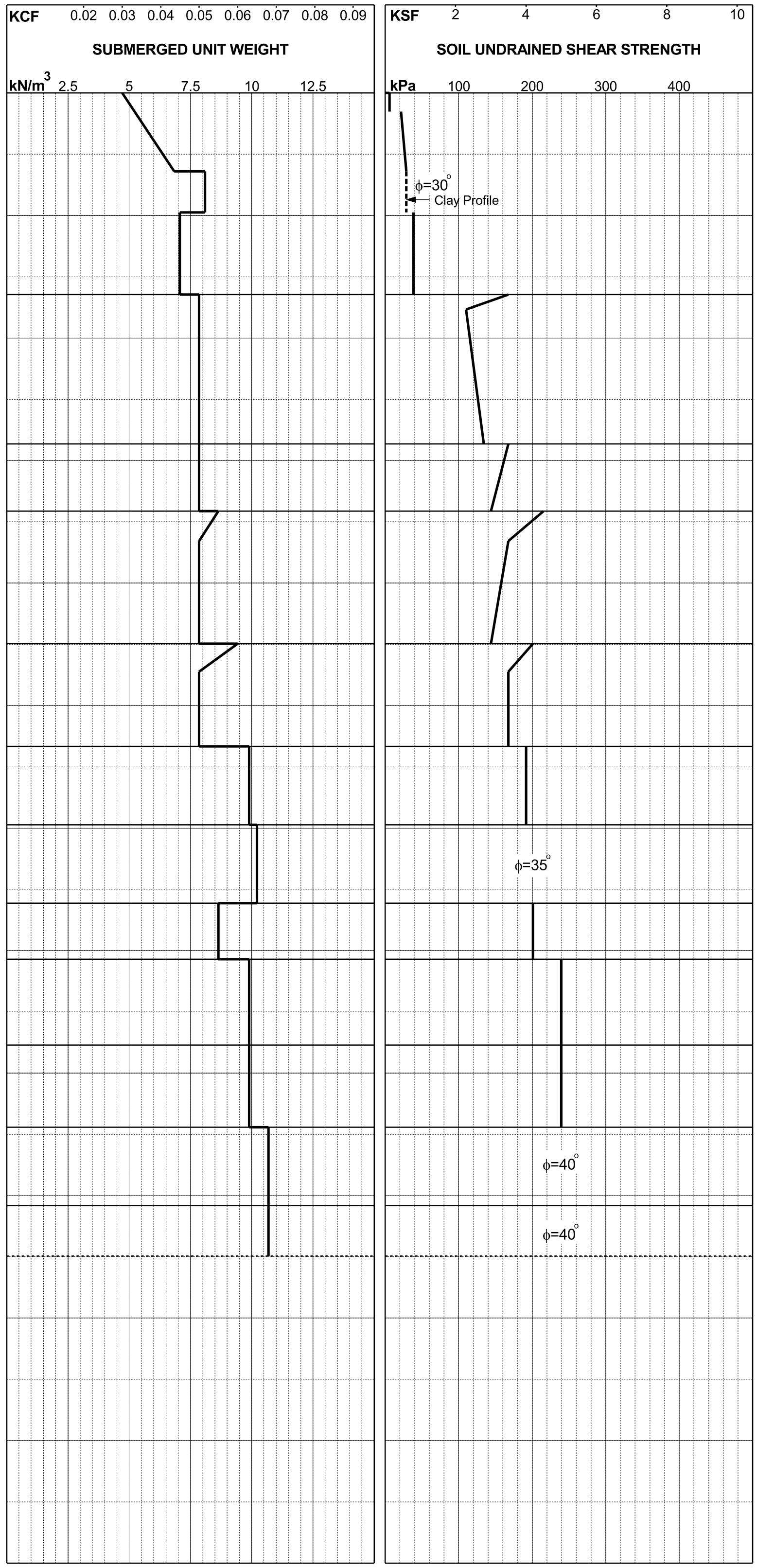
MATERIAL DESCRIPTION

MUDLINE ELEVATION: -9.8m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), soft to firm, dark gray -very loose, olive gray, silty fine sand layer, with many clay pockets, 0.9m to 1.2m -intermixed clay and sand, 6.4m to 7.0m -sand layer, 7.6m to 8.2m -sand layer, 8.5m to 8.8m -silty sand layer with clay pockets, 9.1m to 9.7m (16.5m)	I	YBM
Fat CLAY (CH), very stiff, gray (28.7m)	II	OBM/UAM
Fat CLAY (CH), very stiff, gray (34.1m)	III	OBM/UAM
Fat CLAY (CH), very stiff to hard, gray (45.0m)	IV	OBM/UAM
Fat CLAY (CH), very stiff, gray -sand layer, 48.8m to 49.1m (53.3m)	V	OBM/UAM
Lean CLAY (CL), very stiff to hard, greenish gray (59.7m)	VI	OBM/UAM
Fine to Coarse SAND with silt (SW-SM), dense, gray -silty fine sand below 64.2m (66.1m)	VII	OBM/UAM
Lean CLAY (CL), very stiff to hard, olive gray (70.7m)	VIII	OBM/UAM
Lean CLAY (CL), hard, olive gray (77.7m)	IX	OBM/UAM
Lean CLAY (CL), hard, gray -interlayered sand and clay, below 82.9m (84.4m)	X	LAA
Fine to Medium SAND with silt (SP-SM), dense to very dense, gray (90.8m)	XI	LAA
Fine GRAVEL (GP), very dense, dark gray -sand layer, 91.4m to 92.4m -dense to very dense, fine to coarse sand, at 94.8m	XII	LAA

TOTAL DEPTH: 94.9m BACKFILLED WITH: Cement Grout

ELEV. (m): -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120
DEPTH (m): 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110



IDEALIZED SOIL PROFILE
Pier E05-WB
SFOBB East Span Seismic Safety Project

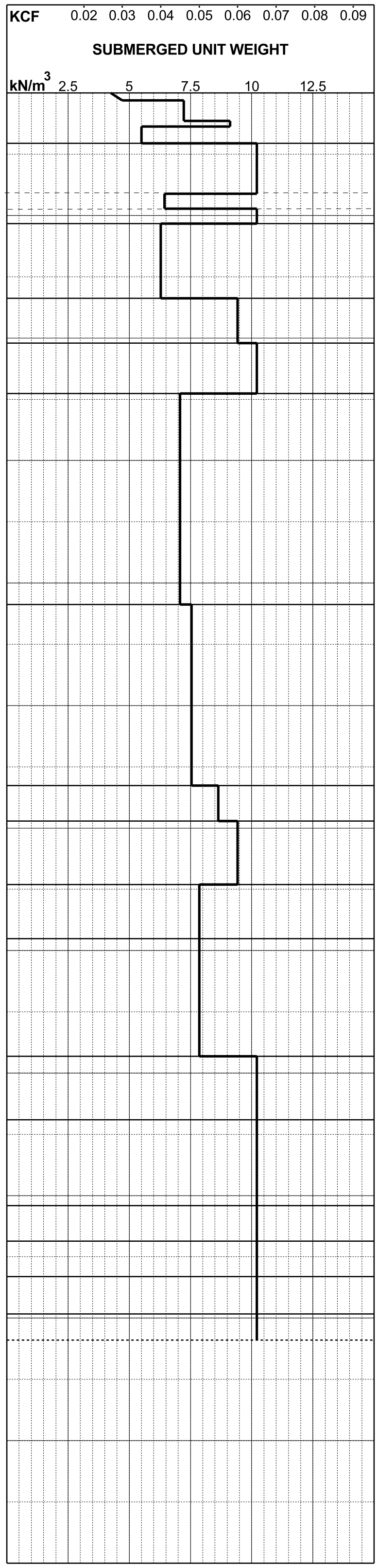
PLATE E05-WB

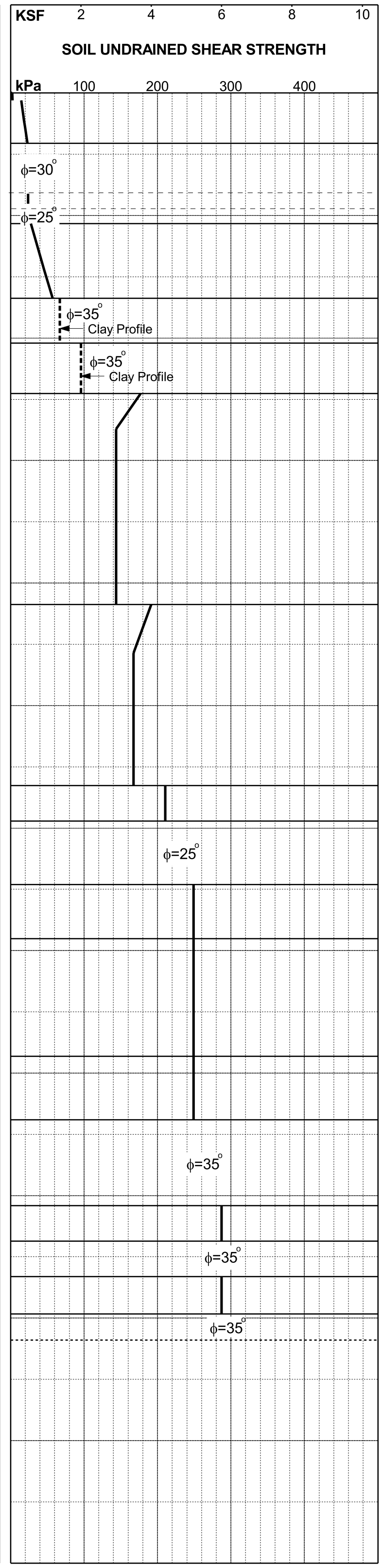
SFOBB Task Order No. 5
Project No. 98-42-0054

Coordinates: E1837289 N647994
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -7.6m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), soft to firm, dark olive gray -medium dense, silty fine sand layer, with clay pockets, 2.3m to 2.6m (4.1m)	I	YBM
Fine SAND with silt (SP-SM), dense, olive gray -firm, dark olive gray fat clay with many shells and shell fragments, 8.2m to 9.4m -medium dense, silty fine sand, 9.4m to 10.5m -with clay at 10.1m (10.7m)	II	YBM
Fat CLAY (CH), firm to stiff, olive gray (16.8m)	III	YBM
Silty Fine SAND (SM), very dense, brown -clay layer with sand seams, 17.4m to 17.7m -fat clay below 18.9m (20.4m)	IV	MPSA
Fine SAND (SP), dense to very dense, gray -fat clay, 22.3m to 22.6m -fat clay, 23.2m to 23.9m (24.5m)	V	MPSA
Fat CLAY (CH), very stiff, gray -silt, 36.0m to 36.6m (41.8m)	VI	OBM/UAM
Fat CLAY (CH), verty stiff to hard, greenish gray (56.5m)	VII	OBM/UAM
Lean CLAY (CL), hard, greenish gray -sand layer, 56.8m to 57.3m (59.4m)	VIII	OBM/UAM
Clayey SILT with sand (ML), very dense, greenish gray -sand with a few clay seams, below 62.2m (64.6m)	IX	OBM/UAM
Fat CLAY (CH), hard, gray -dense sand, 66.6m to 67.5m (69.0m)	X	OBM/UAM
Fat CLAY (CH), hard, greenish gray -dense sand layer, 72.2m to 72.5m (78.6m)	XI	OBM/UAM
Lean CLAY (CL) with sand, hard, greenish gray -fine sand with clay seams, 81.5m to 82.1m (83.8m)	XII	LAA
Fine to Coarse SAND with silt (SP-SM), very dense, gray (90.8m)	XIII	LAA
Lean CLAY (CL), hard, greenish gray to gray (93.7m)	XIV	LAA
Silty Fine SAND (SM), very dense, yellowish greenish brown (96.6m)	XV	LAA
Fat CLAY (CH), hard, yellowish brown (99.7m)	XVI	LAA
Clayey GRAVEL (GC), very dense, yellowish red	XVII	LAA
TOTAL DEPTH: 101.8m BACKFILLED WITH: Cement Grout		FF

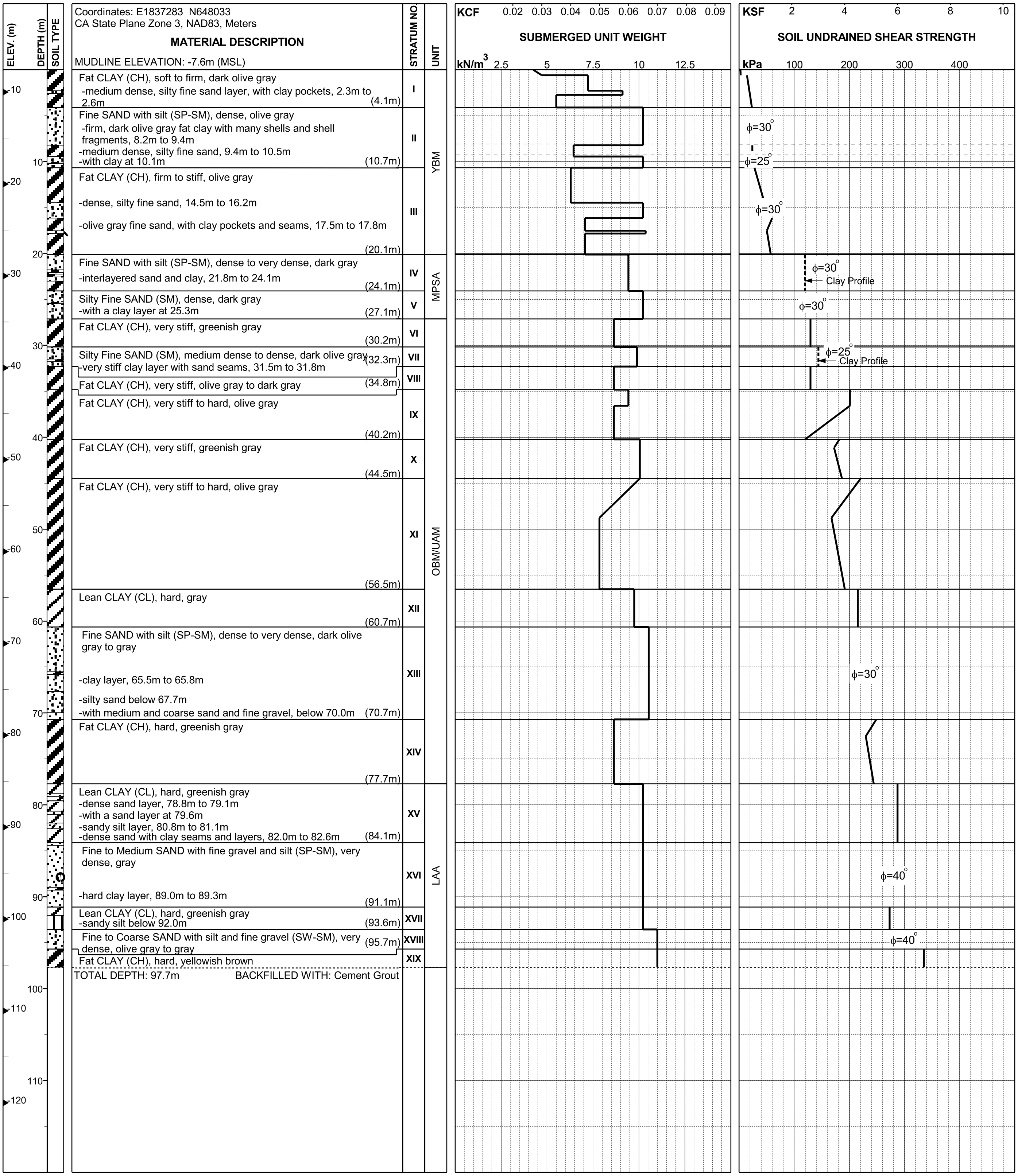




IDEALIZED SOIL PROFILE
Pier E06-EB
SFOBB East Span Seismic Safety Project

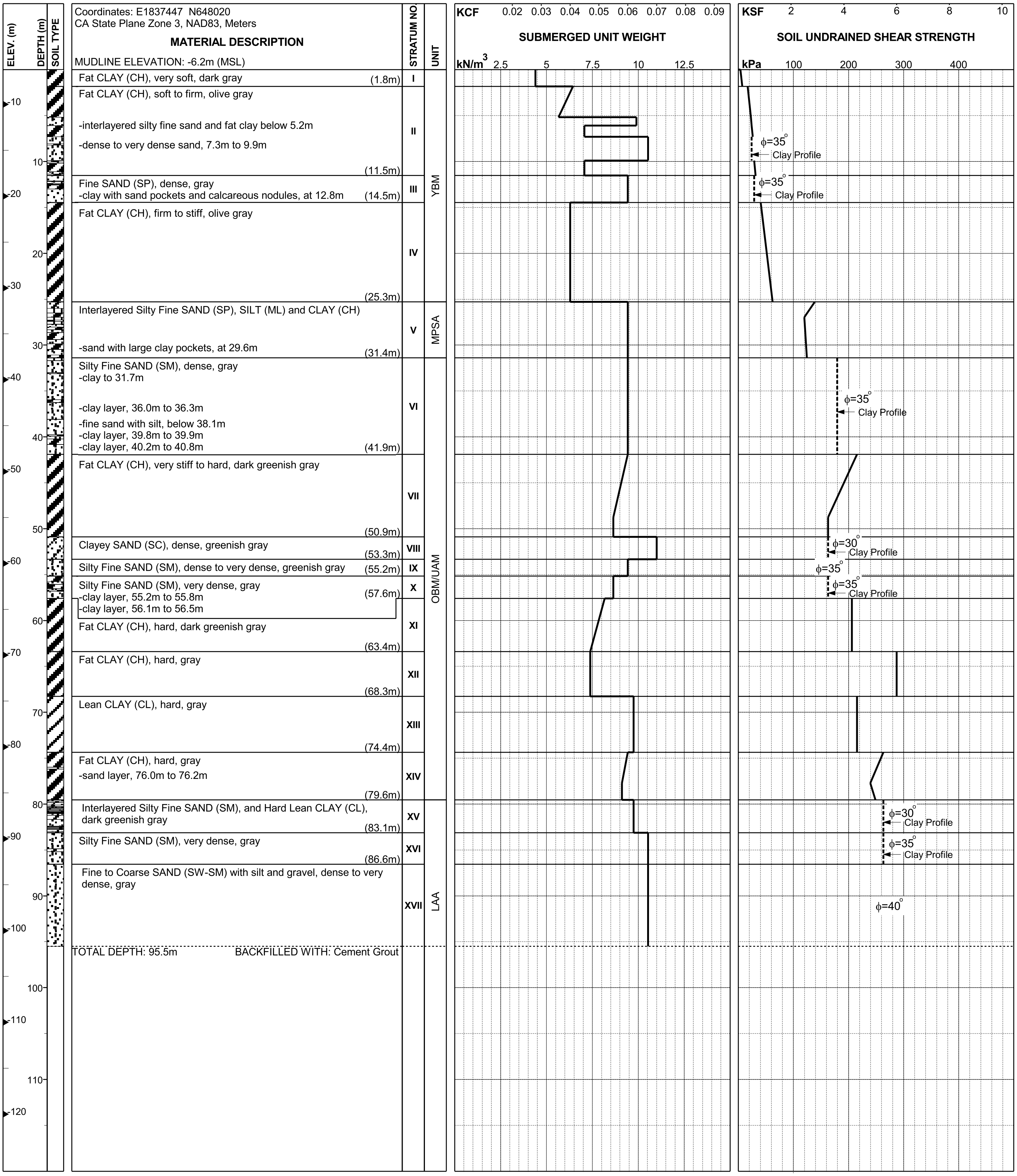
PLATE E06-EB

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E06-WB
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E07-EB
SFOBB East Span Seismic Safety Project

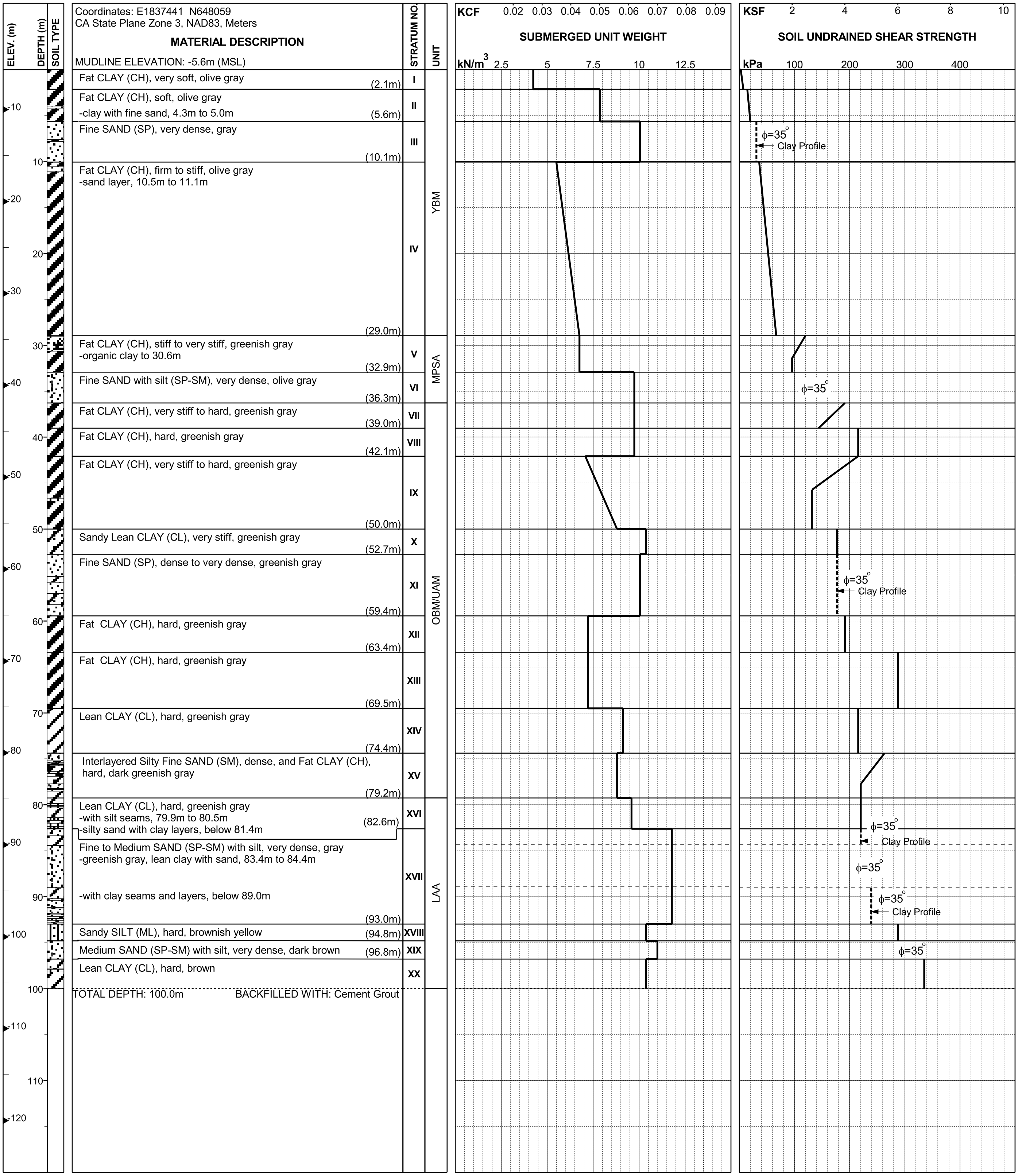
PLATE E07-EB

Coordinates: E1837441 N648059
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -5.6m (MSL)

MATERIAL DESCRIPTION	STRATUM NO.	UNIT
Fat CLAY (CH), very soft, olive gray (2.1m)	I	YBM
Fat CLAY (CH), soft, olive gray -clay with fine sand, 4.3m to 5.0m (5.6m)	II	YBM
Fine SAND (SP), very dense, gray (10.1m)	III	YBM
Fat CLAY (CH), firm to stiff, olive gray -sand layer, 10.5m to 11.1m (29.0m)	IV	YBM
Fat CLAY (CH), stiff to very stiff, greenish gray -organic clay to 30.6m (32.9m)	V	MPSA
Fine SAND with silt (SP-SM), very dense, olive gray (36.3m)	VI	MPSA
Fat CLAY (CH), very stiff to hard, greenish gray (39.0m)	VII	OBM/UAM
Fat CLAY (CH), hard, greenish gray (42.1m)	VIII	OBM/UAM
Fat CLAY (CH), very stiff to hard, greenish gray (50.0m)	IX	OBM/UAM
Sandy Lean CLAY (CL), very stiff, greenish gray (52.7m)	X	OBM/UAM
Fine SAND (SP), dense to very dense, greenish gray (59.4m)	XI	OBM/UAM
Fat CLAY (CH), hard, greenish gray (63.4m)	XII	OBM/UAM
Fat CLAY (CH), hard, greenish gray (69.5m)	XIII	OBM/UAM
Lean CLAY (CL), hard, greenish gray (74.4m)	XIV	OBM/UAM
Interlayered Silty Fine SAND (SM), dense, and Fat CLAY (CH), hard, dark greenish gray (79.2m)	XV	OBM/UAM
Lean CLAY (CL), hard, greenish gray -with silt seams, 79.9m to 80.5m -silty sand with clay layers, below 81.4m (82.6m)	XVI	LAA
Fine to Medium SAND (SP-SM) with silt, very dense, gray -greenish gray, lean clay with sand, 83.4m to 84.4m -with clay seams and layers, below 89.0m (93.0m)	XVII	LAA
Sandy SILT (ML), hard, brownish yellow (94.8m)	XVIII	LAA
Medium SAND (SP-SM) with silt, very dense, dark brown (96.8m)	XIX	LAA
Lean CLAY (CL), hard, brown	XX	LAA

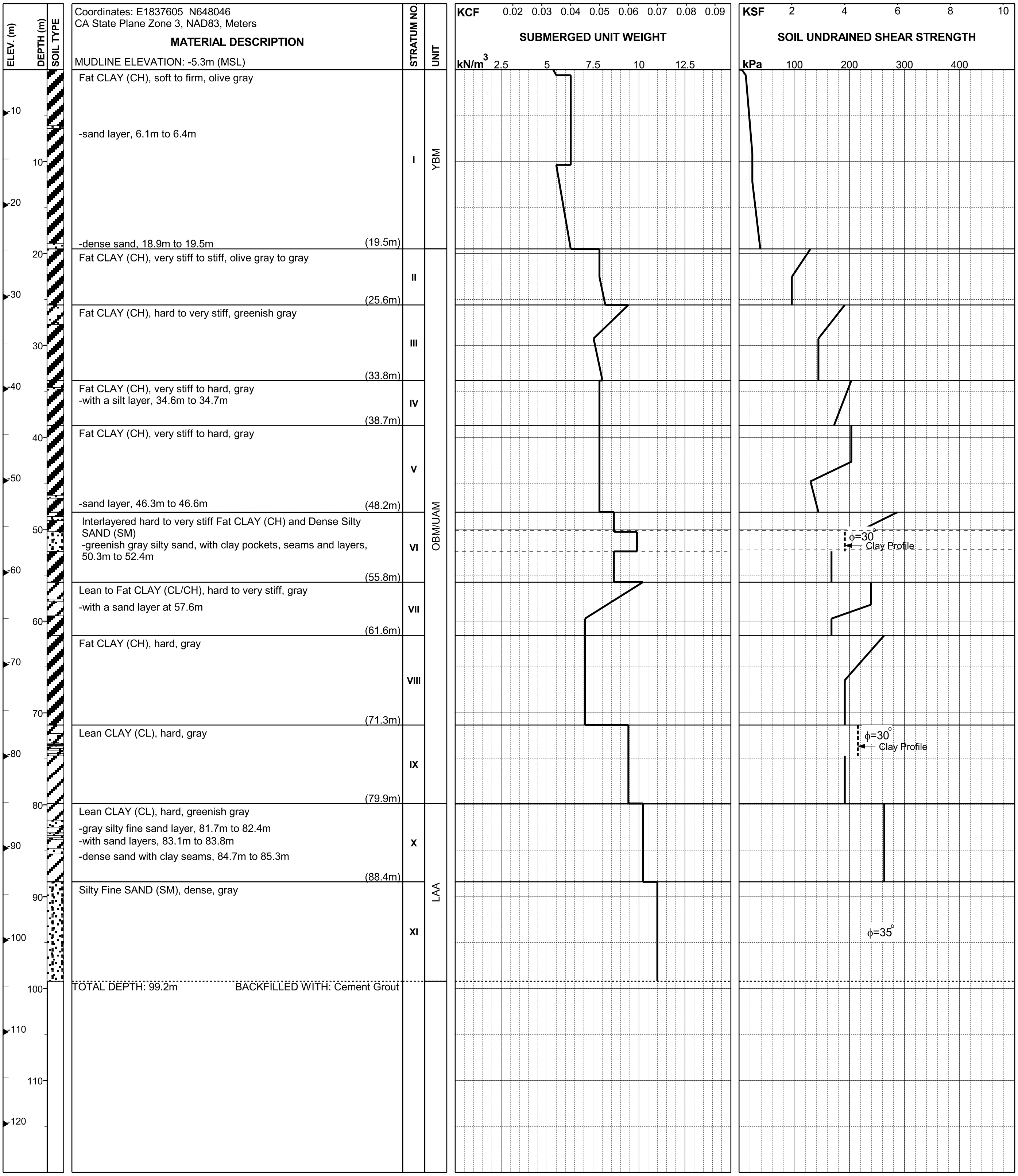
TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout



IDEALIZED SOIL PROFILE
Pier E07-WB
SFOBB East Span Seismic Safety Project

PLATE E07-WB

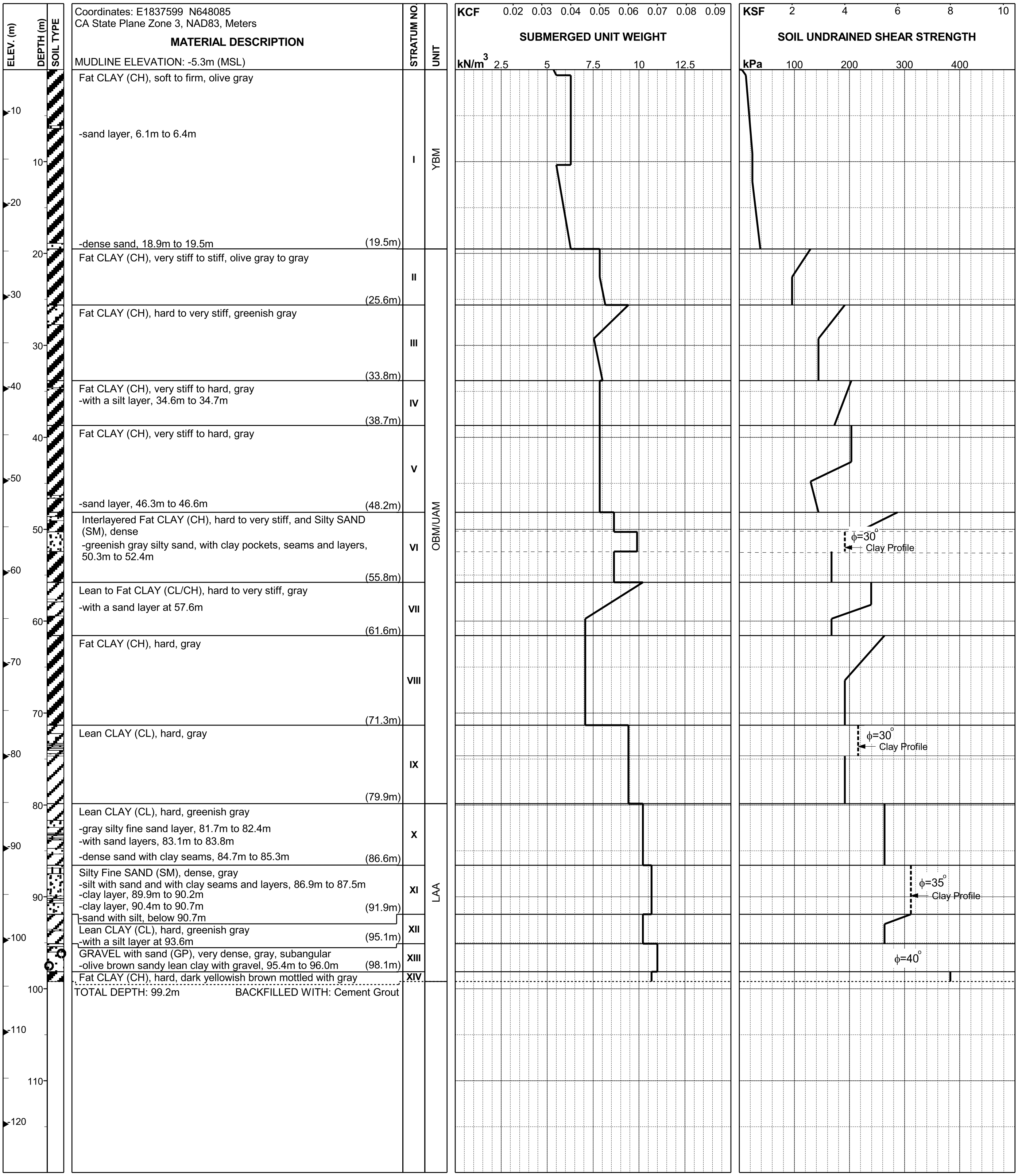
SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E08-EB
SFOBB East Span Seismic Safety Project

PLATE E08-EB

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E08-WB
SFOBB East Span Seismic Safety Project

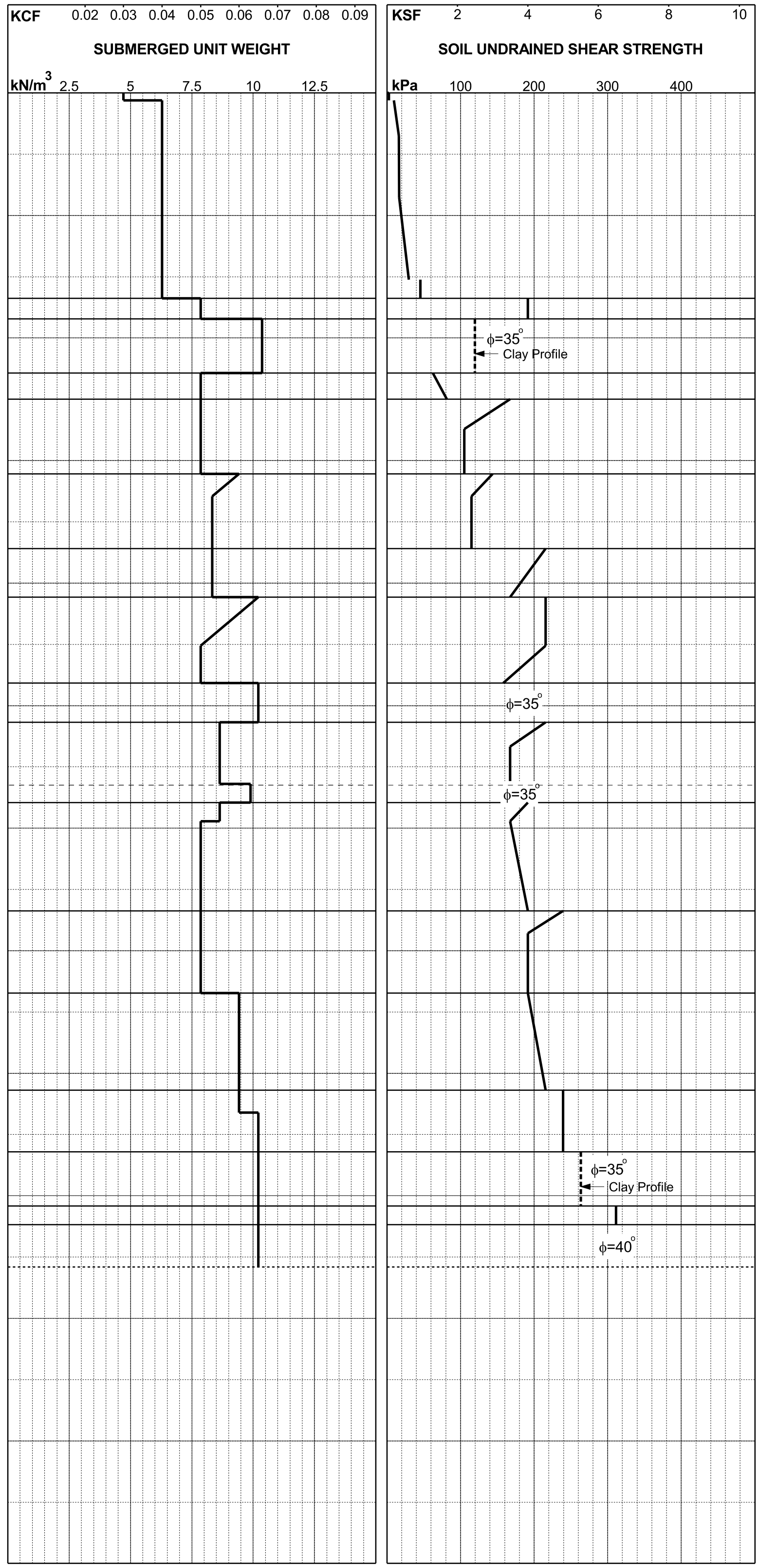
Coordinates: Eastbound: E1837763 N648071
Westbound: E1827757 N648111
CA State Plane Zone 3, NAD83, Meters

MATERIAL DESCRIPTION

MUDLINE ELEVATION: -4.0m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), soft, olive gray -sand layer, 12.2m to 12.5m -sand layer, 13.9m to 14.3m -medium dense silty fine sand, with clay pockets and organic pockets, 15.5m to 15.8m (16.8m)	I	YBM
Lean CLAY (CL), hard -silt layer, 17.5m to 17.8m (18.4m)	II	MPSA
Silty Fine SAND (SM), very dense, gray -clay layer, 19.7m to 20.0m -clay layer, 20.4m to 20.7m (22.9m)	III	MPSA
Fat CLAY (CH), stiff, greenish gray (25.0m)	IV	OBM/UAM
Fat CLAY (CH), very stiff, greenish gray (31.1m)	V	OBM/UAM
Fat CLAY (CH), very stiff, greenish gray (37.2m)	VI	OBM/UAM
Fat CLAY (CH), hard to very stiff, greenish gray -silt layer, 40.4m to 40.7m (41.1m)	VII	OBM/UAM
Fat CLAY (CH), hard to very stiff, greenish gray (48.2m)	VIII	OBM/UAM
Fine SAND with silt (SP-SM), dense to very dense, gray (51.4m)	IX	OBM/UAM
Fat CLAY (CH), hard to very stiff, gray -silty fine sand layer, 54.9m to 55.2m -silty fine to medium sand with trace coarse sand and gravel, below 56.1m (57.9m)	X	OBM/UAM
Fat CLAY (CH), very stiff, olive gray (66.8m)	XI	OBM/UAM
Fat CLAY (CH), hard, dark gray (73.5m)	XII	OBM/UAM
Lean CLAY (CL), hard, gray -silty sand layer, 74.2m to 75.3m -sandy silt, with clay seams and layers, 75.3m to 76.2m (81.4m)	XIII	OBM/UAM
Lean CLAY (CL), hard, gray (86.4m)	XIV	LAA
Silty Fine SAND (SM), very dense, gray -clay layer, 86.9m to 87.2m -clay layer, 89.0m to 89.3m (90.8m)	XV	LAA
Lean CLAY (CL), hard, gray (92.4m)	XVI	LAA
Fine to Medium SAND (SW-SM) with silt and gravel, very dense, gray	XVII	LAA

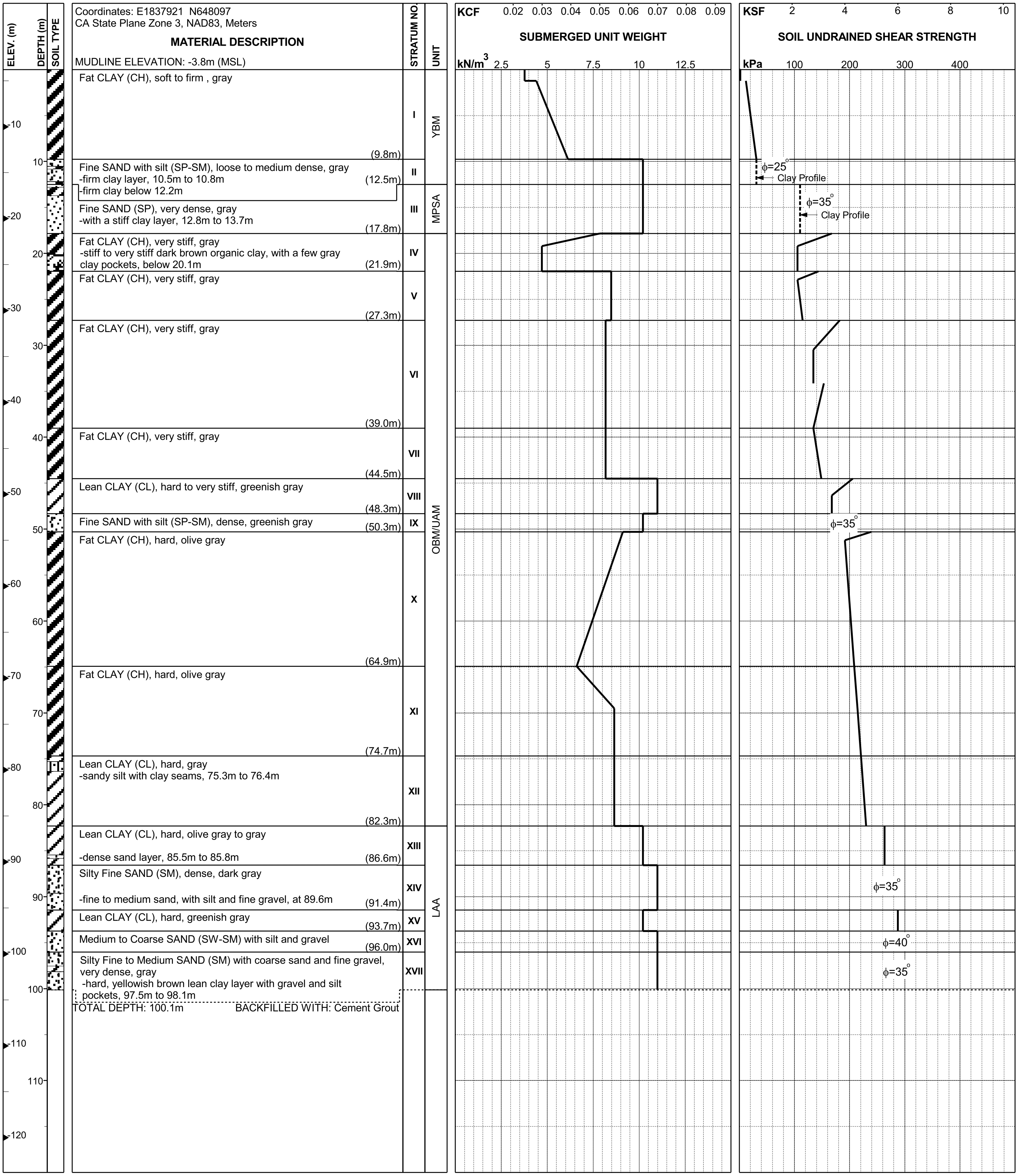
TOTAL DEPTH: 95.8m BACKFILLED WITH: Cement Grout



IDEALIZED SOIL PROFILE
Pier E09-EB and WB
SFOBB East Span Seismic Safety Project

PLATE E09

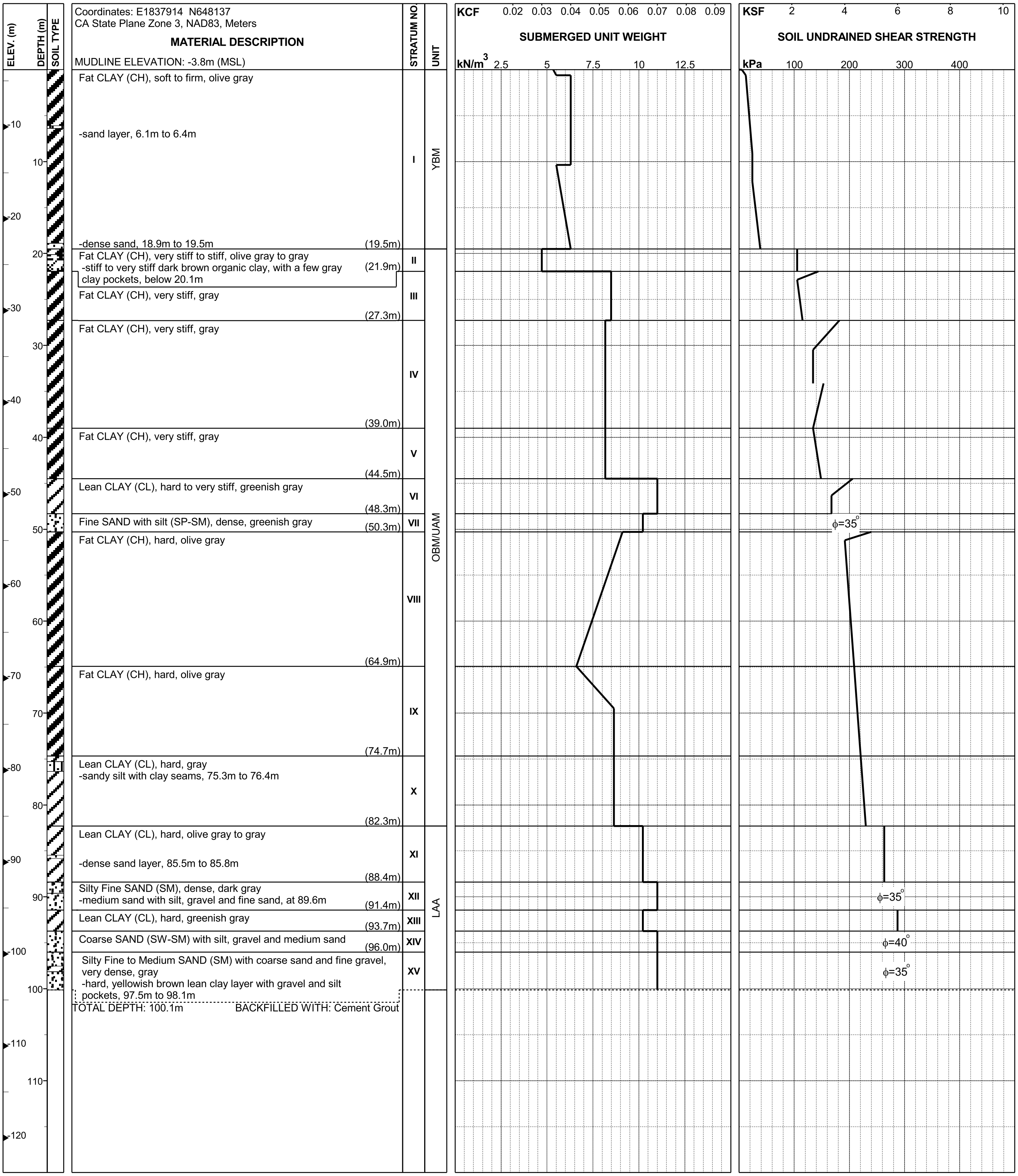
SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E10-EB
SFOBB East Span Seismic Safety Project

PLATE E10-EB

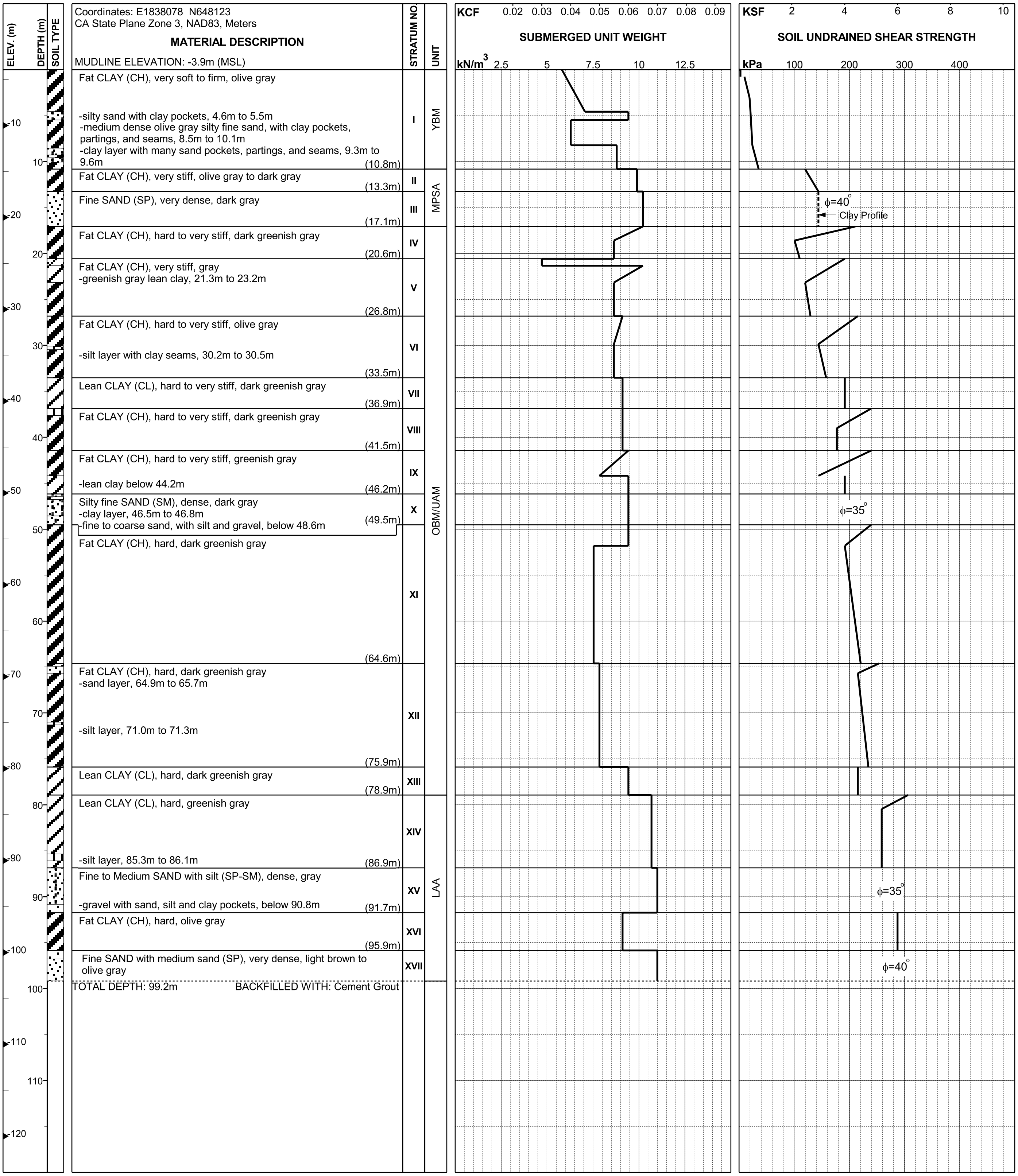
SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E10-WB
SFOBB East Span Seismic Safety Project

PLATE E10-WB

SFOBB Task Order No. 5
Project No. 98-42-0054



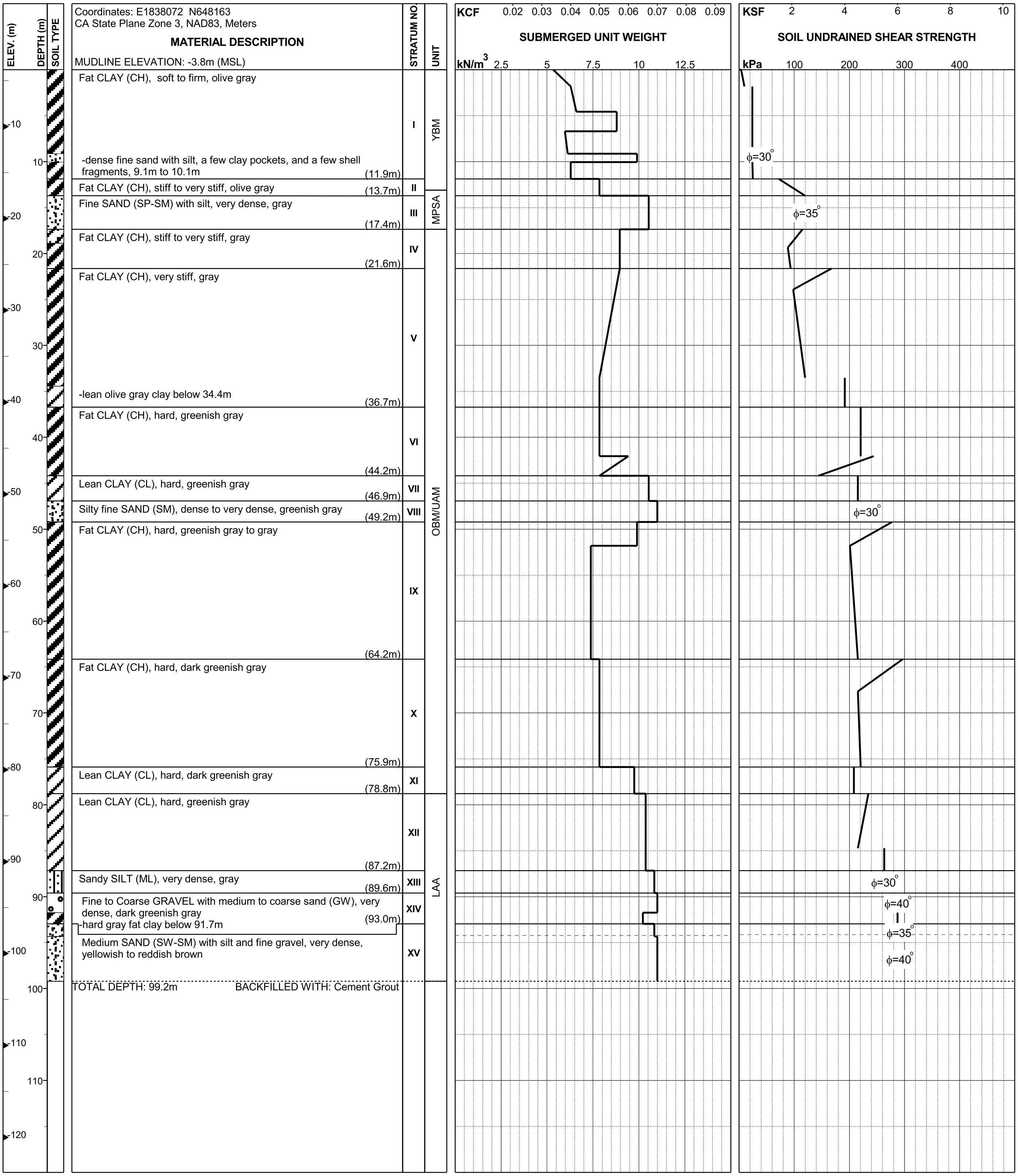
IDEALIZED SOIL PROFILE

Pier E11-EB

SFOBB East Span Seismic Safety Project

PLATE E11-EB

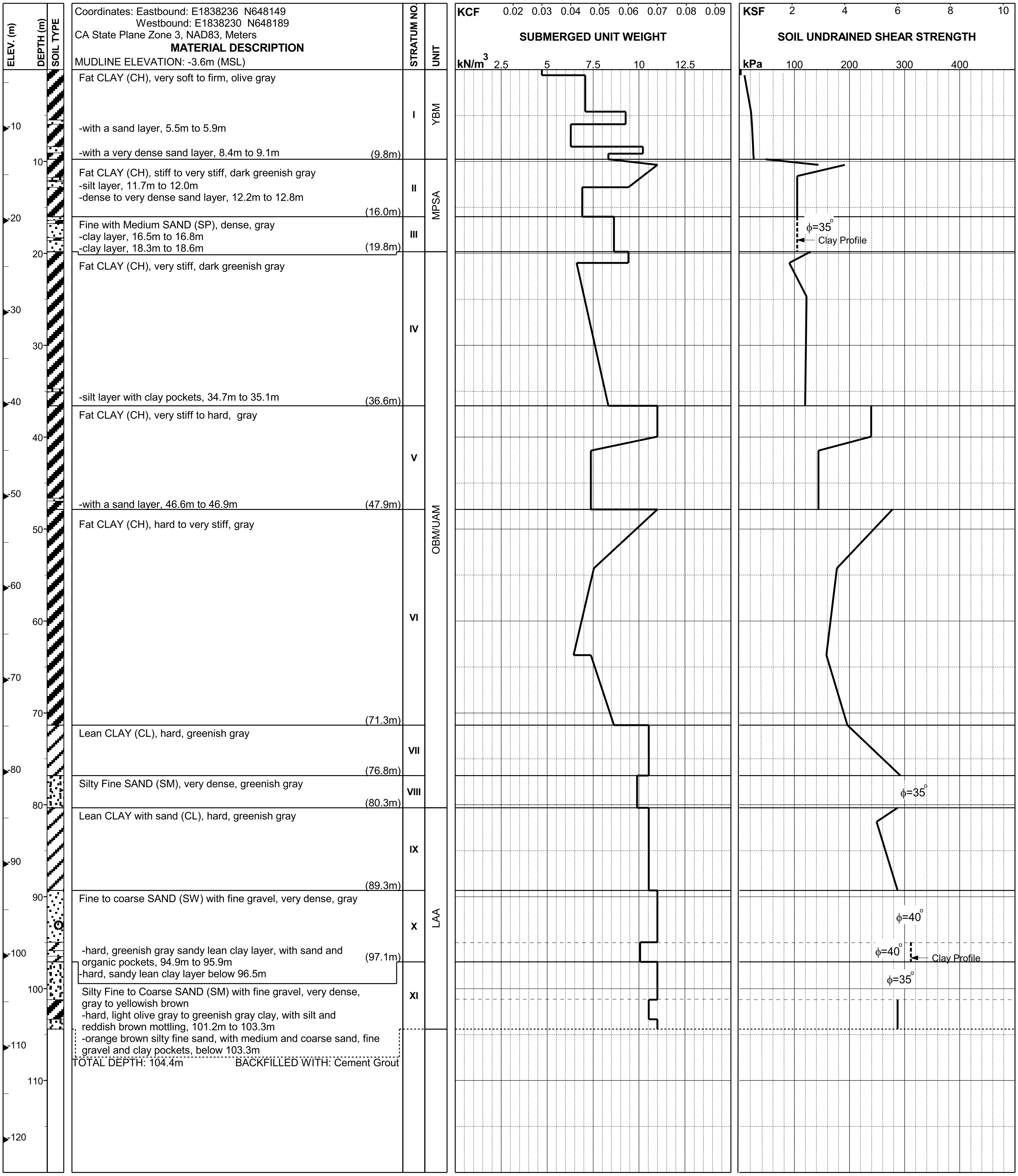
SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Pier E11-WB
SFOBB East Span Seismic Safety Project

PLATE E11-WB

SFOBB Task Order No. 5
Project No. 98-42-0054

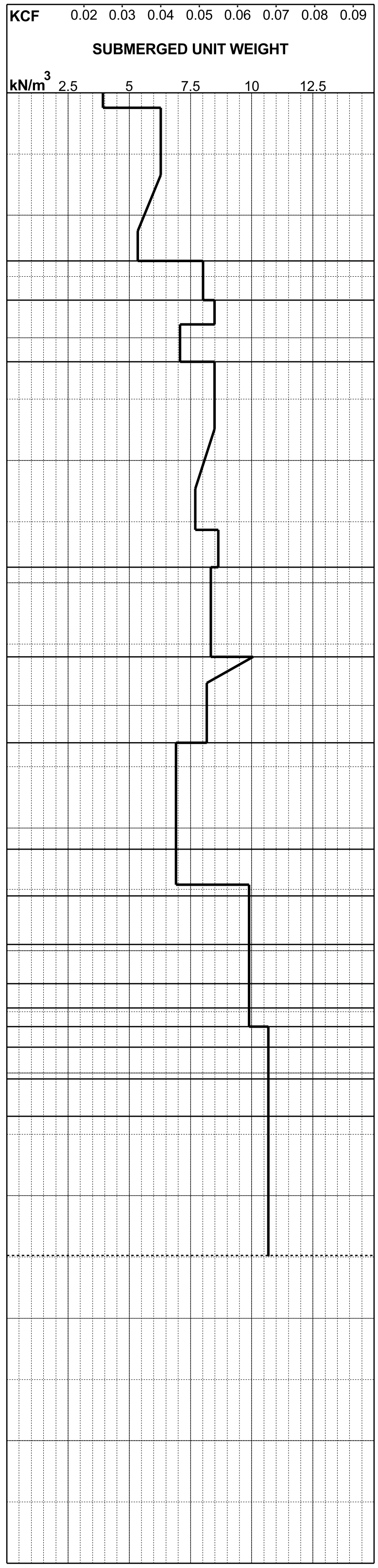


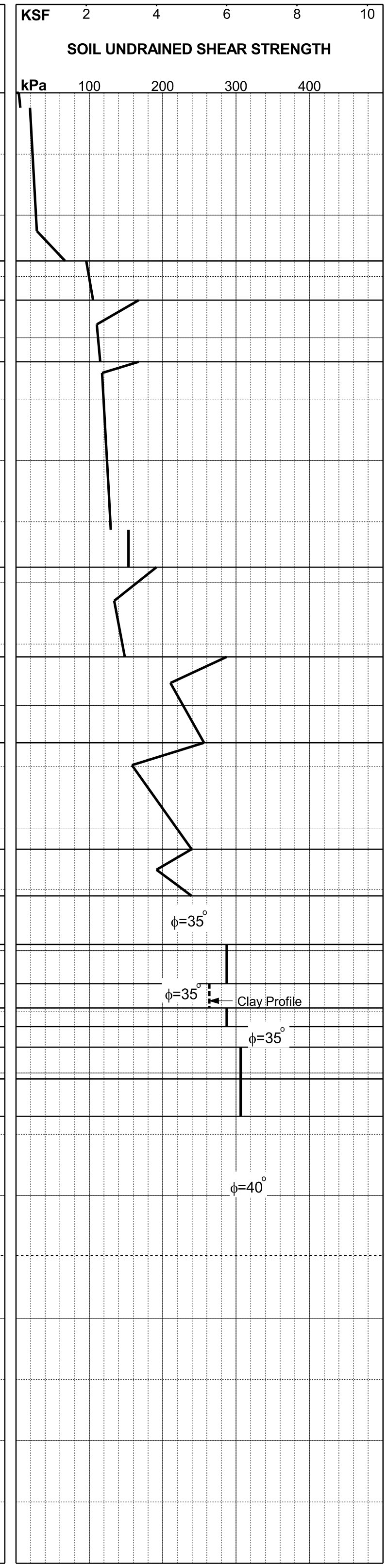
IDEALIZED SOIL PROFILE
Pier E12-EB and WB
SFOBB East Span Seismic Safety Project

PLATE E12

SFOBB Task Order No. 5
Project No. 98-42-0054

ELEV. (m)	DEPTH (m)	MATERIAL DESCRIPTION	STRATUM NO	UNIT
		Coordinates: E1838386 N648174 CA State Plane Zone 3, NAD83, Meters MUDLINE ELEVATION: -3.4m (MSL)		
-10	10	Fat CLAY (CH), soft to firm, olive gray -dark gray silty fine sand, with a few clay pockets, shells and shell fragments, 4.6m to 5.2m -sand layer, 9.6m to 10.1m (13.7m)	I	YBM
-20		Fat CLAY (CH), stiff to very stiff, greenish gray -sand layer, 15.4m to 15.7m (16.9m) -sand layer below 16.5m	II	MPSA
	20	Fat CLAY (CH), very stiff, greenish gray (21.9m)	III	OBM/UAM
-30, -40	30	Fat CLAY (CH), very stiff, greenish gray -interlayered silt and clay, below 35.7m (38.7m)	IV	
	40	Fat CLAY (CH), very stiff to hard, greenish gray (46.0m)	V	
-50	50	Fat CLAY (CH), hard, greenish gray (53.0m)	VI	
-60	60	Fat CLAY (CH), very stiff to hard, olive gray (61.7m)	VII	
		Fat CLAY (CH), very stiff to hard, olive gray -silt layer to 61.9m -silt layer, 64.6m to 65.2m (65.5m)	VIII	
-70		Silty Fine SAND (SM), medium dense to dense, dark greenish gray -clay layer, 65.8m to 66.4m (69.5m) -laminated sand and clay at 66.4m	IX	
	70	Fat CLAY (CH), hard, dark greenish gray (72.7m)	X	
		Interlayered SAND (SP), dense, and CLAY (CL), hard (74.7m)	XI	
		Sandy CLAY (CL), dense, dark greenish gray (76.2m)	XII	LAA
-80		Fine to Coarse SAND (SW) with fine to coarse gravel, dense, gray (77.9m)	XIII	
	80	Lean CLAY (CL), hard, dark greenish gray (80.5m)	XIV	
		Fat CLAY (CH), hard, yellowish brown -sand layer, 80.9m to 81.2m (83.5m)	XV	
-90	90	Silty Fine to Coarse SAND (SM) with fine gravel, very dense, yellowish brown -with a clay layer, 87.2m to 87.9m	XVI	
-100, -110, -120	100, 110	TOTAL DEPTH: 94.9m BACKFILLED WITH: Cement Grout		

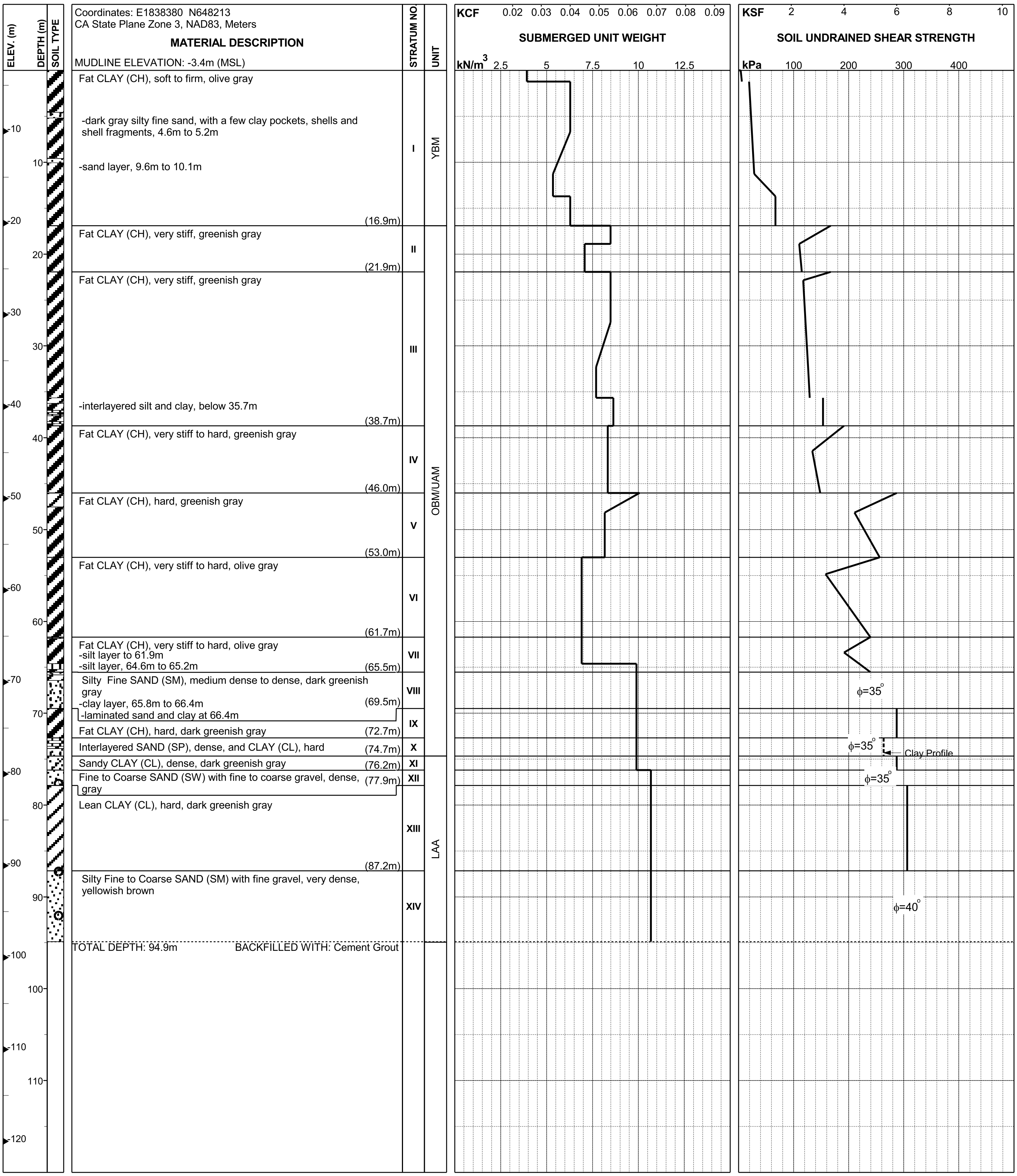




IDEALIZED SOIL PROFILE
Pier E13-EB
SFOBB East Span Seismic Safety Project

PLATE E13-EB

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE

Pier E13-WB

SFOBB East Span Seismic Safety Project

PLATE E13-WB

SFOBB Task Order No. 5
Project No. 98-42-0054

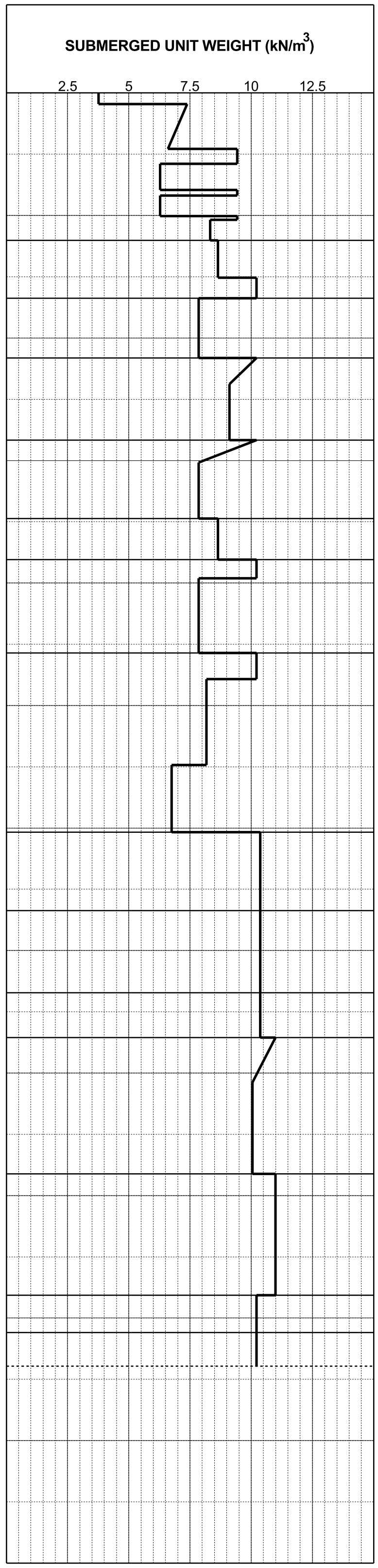
Coordinates: Eastbound: E1838521 N648196
Westbound: E1838514 N648235
CA State Plane Zone 3, NAD83, Meters

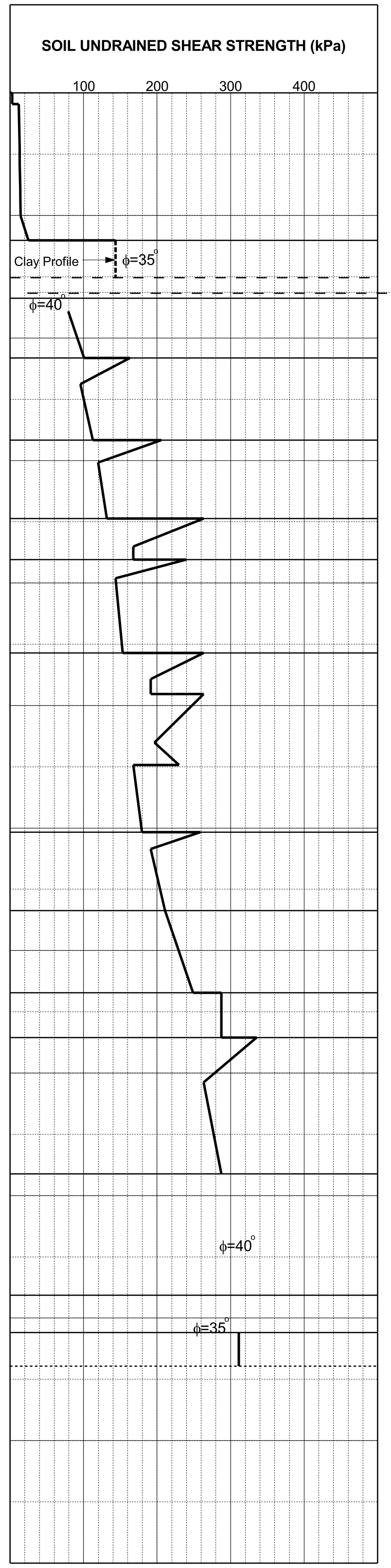
MUDLINE ELEVATION: -3.0m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), very soft to firm, dark gray to olive gray -gray silty fine to fine sand with clay pockets and seams, 4.6m to 5.8m -sand layer, 7.9m to 8.4m -sand layer, 10.1m to 10.4m (12.0m)	I	YBM
Interlayered Silty Fine SAND (SM), dense, gray, and Fat CLAY (CH), very stiff, gray -clay with sand seams, 13.4m to 13.7m -clay with sand seams and pockets, 14.3m to 14.8m (16.8m)	II	MPSA
-sand with clay pockets at 14.8m -very dense fine sand below 15.1m Fat CLAY (CH), stiff to very stiff, gray (21.6m)	III	OBM/UAM
-very dense gray sand, 18.4m to 18.7m -very dense sand with clay seams, 18.9m to 19.5m Fat CLAY (CH), very stiff, gray (28.3m)	IV	OBM/UAM
Fat CLAY (CH), hard to very stiff, gray -silt layer, 30.0m to 30.5m (34.7m)	V	OBM/UAM
Fat CLAY (CH), hard to very stiff, greenish gray (38.1m)	VI	OBM/UAM
Fat CLAY (CH), hard to very stiff, greenish gray to olive gray (45.7m)	VII	OBM/UAM
Fat CLAY (CH), hard to very stiff, greenish gray -with silt layers at 49.1m and 49.4m (60.4m)	VIII	OBM/UAM
Lean to Fat CLAY (CL/CH), hard, greenish gray (66.8m)	IX	OBM/UAM
Fat CLAY (CH), hard, yellowish brown (73.5m)	X	OBM/UAM
Lean CLAY (CL), hard, greenish gray -sand with clay layers, 74.2m to 75.6m (77.1m)	XI	OBM/UAM
Lean CLAY (CL), hard, yellowish brown with light gray mottling (88.2m)	XII	LAA
Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense to very dense, yellowish red -hard lean clay, with iron oxide staining, silty fine sand partings and fine gravel pockets, 95.7m to 96.3m (98.1m)	XIII	LAA
Silty Fine SAND (SM), dense to very dense, yellowish red (101.2m)	XIV	LAA
Fat CLAY (CH), hard, brown -sand below 103.8m	XV	LAA

TOTAL DEPTH: 103.9m BACKFILLED WITH: Cement Grout

ELEV. (m): -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120
DEPTH (m): 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110

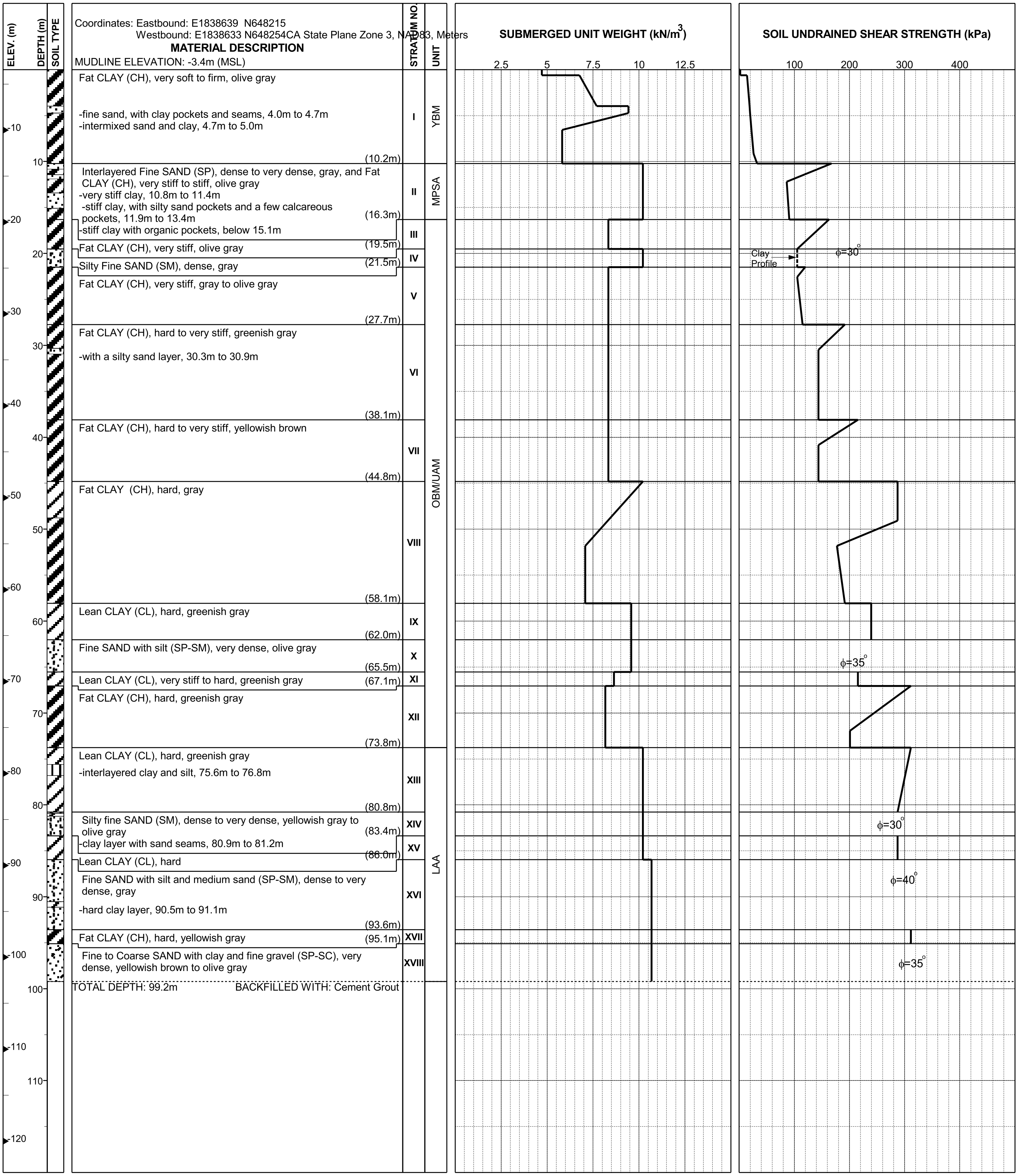




IDEALIZED SOIL PROFILE
Piers E14-EB and WB
SFOBB East Span Seismic Safety Project

PLATE E14

SFOBB Task Order No. 5
Project No. 98-42-0054



IDEALIZED SOIL PROFILE
Piers E15-EB and WB
SFOBB East Span Seismic Safety Project

PLATE E15

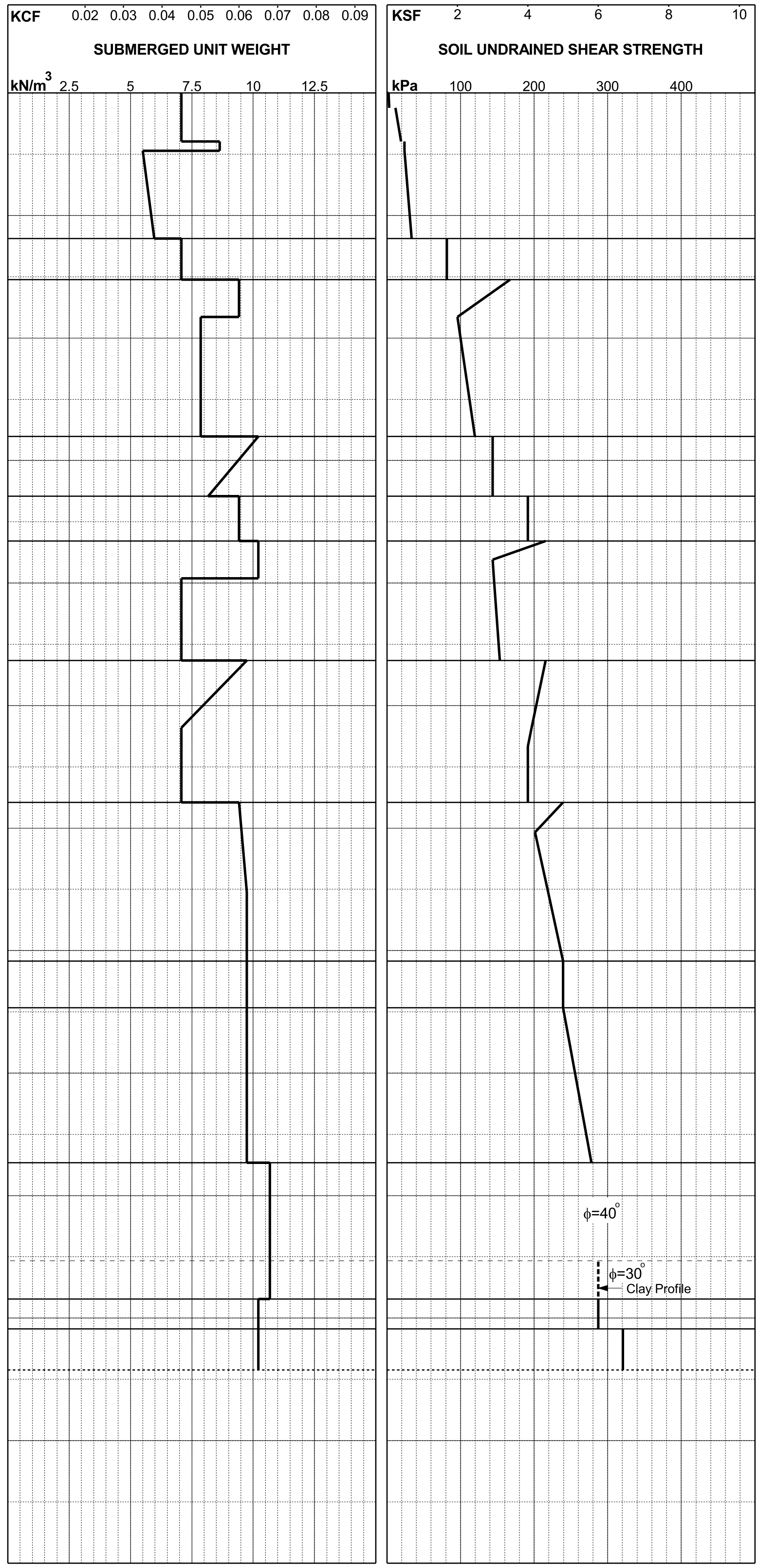
SFOBB Task Order No. 5
Project No. 98-42-0054

Coordinates: Eastbound: E1838728 N648268
Westbound: E1838664 N648259
CA State Plane Zone 3, NAD83, Meters
MUDLINE ELEVATION: -3.4m (MSL)

MATERIAL DESCRIPTION	STRATUM NO	UNIT
Fat CLAY (CH), very soft to firm, olive gray to gray -gray to olive gray silty fine sand with clay pockets, 4.0m to 4.7m -with gas blisters, 4.7m to 7.5m (11.9m)	I	YBM
Fat CLAY (CH), stiff to very stiff, greenish gray (15.2m)	II	MPSA
Fat CLAY (CH), very stiff, greenish gray -sand layer, 15.8m to 15.8m -sand with clay seams and layers, 19.8m to 20.6m (28.0m)	III	OBM/UAM
Fat CLAY (CH), very stiff, gray -sand layer, 30.0m to 30.5m (32.9m)	IV	OBM/UAM
Lean CLAY (CL), hard, gray (36.6m)	V	OBM/UAM
Fat CLAY (CH), very stiff to hard, olive gray -sand layer, 39.9m to 40.2m (46.3m)	VI	OBM/UAM
Fat CLAY (CH), hard, greenish gray (57.9m)	VII	OBM/UAM
Fat CLAY (CH), hard, greenish gray -interlayered clay and silt, 65.2m to 67.7m -sandy lean clay, 68.6m to 70.1m -sand layer, 70.1m to 70.3m -sand with clay seams below 70.4m (70.9m)	VIII	OBM/UAM
Fat CLAY (CH), very stiff to hard, olive gray -sand layer below 73.9m (74.7m)	IX	OBM/UAM
Fat CLAY (CH), hard, brown -interlayered clay and silt, 79.4m to 82.3m -sandy lean clay, 81.7m to 82.9m -sand layer, 82.9m to 83.4m -lean clay below 83.4m -silty fine sand layer, 84.9m to 85.2m (87.3m)	X	LAA
Fine to Medium SAND with silt (SP-SM), dense to very dense, gray -very stiff, brown clayey sand with gravel, 95.4m to 96.3m -clay layer, 96.3m to 96.6m -reddish brown to gray, silty fine to medium sand with coarse sand and fine gravel, at 98.0m (98.5m)	XI	LAA
Fat CLAY (CH), hard, olive gray (100.9m)	XII	LAA
Lean CLAY (CL), hard, olive brown -silt layer, 101.2m to 101.5m	XIII	LAA

TOTAL DEPTH: 104.2m BACKFILLED WITH: Cement Grout

ELEV. (m): -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120
DEPTH (m): 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110



IDEALIZED SOIL PROFILE
Pier E16-EB and WB
SFOBB East Span Seismic Safety Project

PLATE E16